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IN ITS

PRACTICAL RELATIONS.

BY

CHARLES K. MILLS, M.D.,

Professor of Diseases of the Mind and Nervous System in the Philadelphia Polyclinic and College for Graduates in Medicine; Lecturer on Mental Diseases in the University of Pennsylvania; Neurologist to the Philadelphia Hospital.

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While appreciating the honor of having been chosen to open a discussion upon Cerebral Localization in its practical relations, I am, at the same time, deeply impressed with the responsibility imposed by the choice. Difficulties beset my way; and not the least of these springs from the proportions to which the subject has grown. At the Seventh International Congress, in London, in 1881, the very existence of special cortical areas was under heavy fire; but the present discussion has been determined to other channels. In the few years which have elapsed since then great advances have been made, and while different interpretations of phenomena may be still worthy of argument, the guiding principles of localization are so firmly established that the physician and surgeon can use them without question for practical purposes—even to the extent of fearlessly invading with trephine and knife the deep recesses of the brain.

From the clinical and pathological observations of practical physical physicians sprang the great conceptions out of which have developed the science and art of localization. Gall,* from outward form and on uncertain grounds, located speech above the orbits; in 1825 its pathology and morbid anatomy were first clearly indicated by Bouillaud,† who held that in the anterior lobes of the brain resided the organ of speech; and Broca,‡ in 1861, from pathological observations, definitely placed the seat of articulate language in the gyre which bears his name. In 1864, J. Hughlings Jackson,§ suggested

* Gall et Spurzheim, Anatomie et physiologie du système nerveux. Vol. i–iv. Paris, 1810–1819.

† Traité Clinique et Physiologique de l'Encéphalite, p. 284.

‡ Bull. de la Soc. anat., T. vi. Août, 1861.

§ London Hospital Reports, vol. i., p. 459, 1864, and Clinical and Physiological Researches on the Nervous System.

that certain convolutions superintended those delicate movements of the hands which are under the immediate control of the mind; and an observation of Hitzig* that certain ocular movements and other muscular phenomena occurred during the galvanization of the heads of patients, lead in 1870, to those researches with Fritsch, which have immortalized the names of both.†

In a national Congress it might not be out of place to review American work in localization; but time will permit me to recall only a few salient facts. The researches of S. Weir Mitchell‡ on the physiology of the cerebellum constituted an early and important contribution to encephalic localization. From numerous physiological experiments, chiefly on pigeons, both by methods of ablation and of chilling or freezing, he concluded that the cerebellum was a great reinforcing organ, capable of being more or less used in volitional muscular motion; but while believing this he was not prepared to assume that it had no other function.

In 1874, a committee of the New York Society of Neurology and Electrology, as the result of carefully recorded experiments, reported conclusions largely confirmatory of those announced by Hitzig. The committee tested also the effects of excitation of the dura mater.§

Dr. J. J. Putnam,‖ of Boston, in 1874, experimented with faradic currents on the cerebral cortex and the parts immediately beneath. He first found the centres for definite, and nearly or quite uncomplicated movements, and the minimal current strength that was necessary to produce these movements, after which, with a sharp knife he made a cut underneath these centres, leaving a good-sized but thin flap which contained these supposititious centres. Having done this, he found if he irritated as before, leaving the flap in situ, the movements did not occur. Turning the flap up, however, a slightly increased current strength produced the same muscular contractions. When the flap was turned back and adjusted, and the electrode applied on its surface as at first, the contractions were not produced. Three dogs were used in the experiments, which were made by Dr. Putnam at the Physiological Laboratory of the Harvard Medical College, with the assistance of Prof. H. P. Bowditch and Dr. William James. After they were made it came to Dr. Putnam's notice that from the same methods the same results had been obtained in the same year by another observer,

* Untersuchungen über das Gehirn.

† Ueber die elektrische Erregbarkeit des Grosshirns. Reichert and DuBois-Reymond's Archiv., 1870, No. 3.

‡ Am. Jour. Med. Sci., n. s., vol. lvii., 1869, p. 336.

§ New York M. J., 1875, xxi., 225–240.

‖ Boston M. & S. J., 1874, xci., 49-52. Ibid. 1879, c., 260–262.

Braun.* Dr. J. Burdon Sanderson,† also, in 1874, had announced the same fact.

The first reported physiological experiments on the human brain were those of Bartholow,‡ in 1874, who, using both a galvanic and a primary faradic current, passed insulated needle electrodes into the brain of a patient.

In any historical reference to American work the labors of Wood§ and Ott‖ on thermic phenomena must hold a high place.

In 1884, Starr,¶ in a review of American medical literature for twenty-five years before, found records of nearly 500 cases of local disease of the brain, some of great value ; such records have since increased and multiplied, and what is better, have improved in method and accuracy. The numerous contributions of Seguin here rank first. A brain tumor was removed by Hirschfelder and Morse,** of San Francisco, February 15, 1886, the fifth case of such operation. Of 63 cases of intracranial operations tabulated by Dr. Park, 17 have been reported by American neurologists and surgeons.

The surgical aspect of cerebral localization is naturally that which appeals to all as the most practical. In this field unprecedented therapeutic results have been achieved, the crowning triumph being the relief of that most agonizing of human diseases, tumor of the brain.

Fascinated by these achievements, we incline to pass by the results elsewhere wrought—in psychological medicine and medical jurisprudence ; in general symptomatology and diagnosis ; in medical therapeutics and technique. I may, however, be allowed to devote to these a few fleeting words.

Cerebral Localization and Insanity.

Bevan Lewis,†† in 1883, pointed out some of the directions in which studies in cerebral localization might advance our knowledge of insanity, but to those I can scarcely more than allude. He held that the localization of cerebral function was the outcome of the great princi-

* Eckhard's Beiträge zur Anatomie und Physiologie, vii., 2. Also : Centralblatt, Berlin, June 13, 1874.

† Proc. Royal Soc., June, 1874.

‡ Am. J. M. Sc., Philada., 1874, n. s., lxvii., 305–313.

§ Fever: A Study in Morbid and Normal Physiology. Smithsonian Contributions to Knowledge. November, 1880.

‖ Jour. Nerv. and Ment. Dis., April, 1884. Philadelphia Med. News, July, 1885. Jour. Nerv. and Ment. Dis., vol. xiv., No. 3, March, 1887. Ibid. No. 7, July, 1876, p. 428. Ibid., vol. xiii., No. 2, February, 1888.

¶ Am. J. M. Sc., Phila., 1884, n. s., lxxxvii., 366–391.

** Pacific M. and S. J., San Francisco, 1886, xxix., 210–216.

†† Brit. M. J., London, 1883, ii., 624–628.

ple of evolution carried to its logical issues ; that the alienist should rivet his attention upon the changes undergone by the material substrata of mind ; that he should strictly and closely study the objective manifestations of mental activity ; that he should learn to examine the various limited lesions of the cortex as to area, depth, localized atrophy, relative bulk of convolutions, and tracts of ascending and descending degeneration.

Numerous isolated cases have been reported in which special mental phenomena have accompanied lesions and defects localized in particular regions—cases of lesion of the frontal lobes with affection of the intellect ; of other cortical lesions with disturbance of a speech and real or apparent mental impairment ; of others with hallucinations, visual, aural, tactile, olfactory, and gustatory; of delusion, hallucinatory or otherwise, with arrested or aberrant development of fissures and gyres. In particular, a considerable collection of visual hallucinations and delusions with localized lesions have been reported. Sir J. Critchton-Browne,* Spitzka,† and others, have contributed valuable localization observations from studies in general paralysis of the insane.

Mickle‡ has shown that lesions of the cortical sensory centrea of the cerebrum are connected in an intimate way with the production of most of the hallucinations in progressive paresis ; that from the cerebral localization point of view use may be made of the distribution of the cerebro-meningeal adhesions and the cortical changes associated therewith ; and that in all cases of visual hallucinations the angular gyre is not affected in the marked manner one would anticipate, on the theory that it is the sole cortical visual centre ; nor in cases of auditory hallucinations is the first temporal, viewing it as the sole cortical centre. The morbid anatomy of progressive paresis, he therefore believes, fails to support the exclusive view that these gyres are the sole centres of sight and hearing. The supra-marginal convolution is affected more than the angular in those with visual hallucinations, and the adhesions are often well marked on the posterior parietal lobule. The second temporal gyrus seems to suffer more than the first in cases with auditory hallucinations taken collectively.

Trephining has been performed in many cases of insanity during the last few years, a fair percentage of the operations having been guided at least in part by the principles of localization.

* West Riding Reports, vol. vi., p. 170.

† Insanity: Its Classification, Diagnosis and Treatment. Article on Paretic Dementia.

‡ Jour. Men. Sc., Oct. 1881 ; Jan. and April, 1882.

Two of the recent cases of brain operation, reported by Bennett and Gould* and by Macewen,† open a possible new field for surgical interference in insanity. In the case of Bennett and Gould, the patient had received a violent blow on the right side of the head and had a scalp wound without apparent injury to the skull. Pressure on the cicatrix caused the sensation of a flash of light followed by unconsciousness for one or two seconds. The patient had no paralysis, loss of sensation, or other symptoms, but was subject to left unilateral convulsions with loss of consciousness, commonly followed by violent mania. The attacks were usually preceded by a bright red flash of light, and were succeeded by what appeared to be threatening visual hallucinations. The scar was over the region which corresponded with the angular gyre. A large trephine opening was made by Mr. Gould, bone and dura mater were removed, and exploration was made in different directions in the brain, but nothing abnormal was detected. Five months later the patient was apparently well having had no attack during that time, although for six years before he had had on an average one fit a week. After his recovery he seemed to forget all about the hallucinations. Dr. Bennett in another case, observed similar hallucinatory phenomena, and after death the angular gyre was found to have been injured. Such cases are of importance as opening the question of the propriety of excising cortical areas as a method of treatment in insanity as well as epilepsy, when certain subjective phenomena such as hallucinations of sight and hearing can be given a local habitation in the brain.

Macewen's case was one of psychical blindness. The patient had received an injury about a year previously and suffered from deep melancholy, and strong homicidal impulses directed against his family and relieved by paroxysms of pain in the head of indefinite seat. Prior to receiving this injury he was perfectly free from such impulses and had led a happy life with his family. Behind the angular process was a slight depression, which could not account for his symptoms. No motor phenomena were present, but on minute inquiry it was discovered that immediately after the accident and, for about two weeks subsequently, he had suffered from psychical blindness. The angular gyre was exposed for operation, and it was found that a portion of the internal table of the skull had been detached from the outer, and had exercised pressure on the posterior portion of the supra-marginal convolution, while a corner of it had penetrated and lay imbedded in the brain. The bone was removed from the brain and re-implanted in proper position, after which he became

* Brit. Med. Jour., Jan. 1, 1887. † Lancet, August 11, 1888.

greatly relieved in his mental state, though still excitable. He made no further allusions to his homicidal tendencies.

Cases of double personality and double consciousness, and of unilateral hallucination, like the following reported by Magnan,* may eventually receive their proper interpretation through investigations in localization. Magnan holds that there are hallucinated individuals who hear on one side agreeable things and on the other side unpleasant. He had had under observation four cases of this kind, of which one was reported in detail. The case was one of primary monomania, complicated with epilepsy. On the right side disagreeable statements were made ; on the left ambitious ideas were conveyed. These latter hallucinations were obviously secondary to the first. He concluded, first, that these unilateral hallucinations on opposite sides were independent of local lesion ; that they did not differ from other hallucinations ; that they proved the double action and functional independence of the two hemispheres ; that analogous phenomena were noticed in hypnotic states ; and that their existence demonstrated the action of separate sensorial centres in the cortex.

Contributions of Cerebral Localization to General Medicine and Therapeutics.

The vast improvements in precision both in examining and describing the symptoms of nervous disease ; and in making and recording the results of autopsies have been largely due to the stimulus to exactness which has been given by the science of cerebral localization which has at its very foundation topographical precision.

The contributions of cerebral localization both to general and local symptomatology, if carefully brought together, would furnish material for an elaborate address. A flood of light has been thrown upon the nature of epilepsy, or rather epilepsies. Many old differential symptoms, some of them once regarded as pathognomonic, have been swept away, and better and surer criteria have been substituted in their place. The clinical teacher no longer announces that unconsciousness is the one sure sign of epilepsy, and the preservation of consciousness of hysteria ; but the question of consciousness becomes a relative one in the consideration of both diseases. We are slowly getting the data for a really scientific classification of epilepsy into reflex, toxic, cortical, bulbar, and spinal. As Mr. Horsley has recently shown, it is no longer necessary to consider hystero-epilepsy, epileptiform seizures, laryngus stridulus, and eclampsia as altogether apart from epilepsy.

* Journal de Médicine de Bordeaux, Sept. 30, 1883.

Not a few symptom-groups or symptoms formerly not understood at all, and some of them regarded as independent diseases, have been given their proper positions ; such affections, for instance, as athetosis, tetany, and some spastic diseases of children. Vagueness has given place to clearness with reference to such affections as cerebral softening ; and new light has been thrown upon such common and important diseases as tubercular meningitis, particularly as it affects the convexity of the hemispheres.

Now and then a new experiment or observation on cerebral localization has let in the light upon some obscure symptom or condition known to the physician. That peculiar perversion of sensory localization known as allochiria was noticed, for instance, by Horsley and Schäfer,* as the result of lesions produced by them in the limbic lobe.

Something has been accomplished with reference to the action of drugs on localized cerebral areas. I might point to the investigations of Albertoni † as to the augmentation of the excitability of the cortex by atropine, and the action of bromide of potassium in reducing the same excitability, a conclusion which has since been confirmed by Rosenbach and others, and is in accord with all clinical experience ; to the work of Luciani and other Italian observers on chinconidine and pyrotoxine as epileptogenic agents ; and to the experiments of Tamburini, Seppilli, Hitzig, and Franck into the effects of anæsthetics and narcotics on critical areas. Franck‡ has thoroughly investigated the effects of curarization on cortical excitability, and some of his results may prove of medico-legal importance in the study of masked or hidden epilepsy. Danillo, Magnan, and Franck have made important observations on absinthine epilepsy.

Experiments and discoveries like those of Eulenberg and Landois, § Wood,‖ Ott,¶ Richet,** Aronsohn and Sachs,†† Wood, Reichert and Hare,‡‡ and Girard,§§ on the existence and phenomena of heat centres in the brain, have been of practical value in throwing light on

* Phil. Trans. Royal Soc. of London, vol. clxxix, (1888), B. pp. 1–45.

† Cortical Epilepsy. Experimental Researches. Synthetic Review. By Greuseppe Seppilli, M.D., Alienist and Neurologist, January, 1885. Translated by Joseph Workman, M.D., from the Rivista Sperimentale, 1884.

‡ Leçons sur les Fonctions Motrices du Cervean, Par le Dr. François-Franck, Paris, 1887.

§ Compt. rend. Acad. de Sc. Par., 1867, lxxxii., 564–567. ‖ Op. cit. ¶ Op. cit.

** Bulletins de la Société de Biologie, March 29, 1884.

†† Deutsche Medicinische Wochenschrift, No. 51, 1882, and Pflüger's Archiv.

‡‡ Therapeutic Gazette, vol. ii., 3 s., No. 9, September, 1886, p. 577.

§§ Arch. de Physiol., norm. et path., Paris, 1886, 3 s., viii., 281–299.

the mechanism of fever, and on the action of special drugs and different modes of treatment on forms of high temperature. I will refer very briefly to some of the experiments and inferences of these observers, simply to show their practical tendencies.

Wood, for instance, holds that with the facts of his experiments in mind, the theory of a causation of fever becomes very plain. "It is simply a state in which a depressing poison or a depressing peripheral irritation acts upon the nervous system which regulates the production and dissipation of animal heat; a system composed of diverse parts so accustomed to act in unison continually in health, that they become as it were one system, and suffer in disease together. Owing to its depressed, benumbed state, the inhibitory centre does not exert its normal influence upon the system, and consequently tissue change goes on at a rate which results in the production of more heat than normal, and an abnormal destruction and elimination of the materials of the tissue. At the same time the vaso-motor and other heat dissipation centres are so benumbed that they are not called into action by their normal stimulus (elevation of the general bodily temperature), and do not provide for the throwing off of animal heat until it becomes so excessive as to call into action by its excessive stimulation even their depressed forces. Finally, in some cases of sudden and excessive fever, as in one form of so-called cerebral rheumatism, the enormous and almost instantaneous rise of temperature appears to be due to a complete paralysis of the nervous centres presiding over heat production and dissipation."

Girard,* as the result of certain experiments on rabbits, concludes that the cerebral centre of thermo-genesis is in the corpus striatum. Lesion of the median portion produced well marked increase of heat, and this was not the result of spasm of vaso-constrictor nerves of the skin. Exciting the region electrically caused a notable increase of heat, showing that this resulted from excitation and not from paralysis. Similar excitation caused increase of urea, indicating an increase of combustion in the organism, which was accompanied by considerable emaciation. Girard believes this apparatus or centre increases the heat under excitation, and notably influences the regulation and production of heat; also that artificial increase of heat is not identical with that of fever. Increased production, and at the same time diminished dispersion of heat, from the body are, according to his view, the two conditions essential to fever.

One of the latest contributions of Ott is on the heat centres of the cortex cerebri and pons varolii. He found that when in his experi-

* Gazetta Degli Ospitali, Aug. 17, 1887.

ments upon rabbits, a puncture was made just in front of the ear into the cortex, there ensued a fugitive rise of temperature ; and this observation led him to try in cats the effects of removal of areas of the cortex in this and other regions. A point at the juncture of the supra-Sylvian and post-Sylvian fissures was found to have the highest thermic value. Other parts of the brain, with the exception of the cruciate centres, had but small effect upon the temperature. The rise of temperature after injury to the Sylvian centres was from three to four degrees, and continued till the death of the animal, which was usually about the fifth or sixth days. The calorimetric investigations showed that either immediately, or at the end of twenty-four hours, the heat production and heat dissipation were increased ; after that they usually fell below normal, although the temperature remained elevated, with a weight decreasing daily. He believes that this increase of heat production was not due to secretory changes ; as pulse and pressure both rose for a short period, and then fell to a certain extent below normal, although the temperature was then rising.

The mechanism of temperature production, according to Ott, is : (1) Thermotaxic centres, cruciate and Sylvian of Eulenberg and Landois ; (2) Thermotaxic and thermo-genetic centres—the centre about Schiff's crying centre, and the extra striate, (Sachs and Aronsohn), and the thalamic centres ; (3) Thermogenetic centres—spinal centres.

"It is probable," says Ott, "that after injury to the cortical heat centre, the basal and spinal thermogenetic centres are temporarily permitted to obtain the upper hand, but that shortly the other cortical heat centres bring the thermogenetic centres into subjection, and thus reduce the heat production. In the case of lesion of the basal and spinal thermogenetic centres, for a short period they primarily overcome the cortical centres, but finally succumb to the domination of the thermotaxic centres of the cortex. In other words, the Sylvian and cruciate centres constantly antagonize the basal and spinal thermogenetic centres. It is also probable that under certain impulses the cortex and basal centres combine together to antagonize the spinal thermogenetic centres. It would seem that an injury to the thermotaxic or thermogenetic apparatus sets up a fever which is primarily accompanied by increased production and dissipation ; but they soon fall below normal, whilst the fever continues till the lesion is repaired. This would lead to the belief that in continued fever the generation of a ptomaine is continuously carried on for some time, and thus keeps up the fever."

Scarcely anything as yet has been contributed by these investigations to the surgical aspects of the question ; but a case reported by Mr. Page* has at least some suggestive value, and is the only one to

* Lancet, London, 1887, ii., 1216.

which I will allude. A man, from a fall, had a wound one inch in length in the right parieto-occipital region. He was put to bed and became dull and apathetic ; his temperature rose until it had reached 105° F., but otherwise he presented no symptoms that could be determined. Trephining was performed over the posterior part of the temporo-sphenoidal lobe. The patient's high temperature rapidly subsided and he recovered without other symptoms.

Before leaving the consideration of these questions of general symptomatology and therapeutics, it might be well briefly to refer to what has been accomplished in cerebral localization with reference to some of the organic or involuntary functions. Are there circumscribed localized areas in the cerebrum which are capable of producing certain so-called organic or involuntary effects, or effects which may be classed as somewhere between the purely voluntary and the involuntary? In other words, to put the question in its simplest expression, have we centres—comparable to those which give definite motor reactions—for such functions as those of respiration, heart-action, vascular tone, oculo-pupillary movements, the secretion of sweat, saliva, and bile, or the excretion of urine? No one has studied this subject with the thoroughness and originality of François Franck in his great work on the motor functions of the cortex, to which reference has already been made. His conclusions are based chiefly upon the results of irritation of various regions of the brain. He found excitation of the brain in various regions of the cortex efficient to produce organic and partly organic manifestations, but such areas were not circumscribed and invariably the same. Changes in respiration, arrest or increase of the movements of the heart, flushing or paling more or less local or general, suppression or increase in the flow of saliva, sweat, bile, urine, etc., could all be brought about by experimenting upon the cerebral cortex of dogs and monkeys. Such results, however, he does not believe should be regarded as simple reactions comparable to the definite movements caused in face or limb by irritation of the centres assigned to these parts. They are complex results more comparable to the reflex effects produced from irritation of sensory surfaces anywhere. He shows that the suppression of the cerebral region, whose excitation so clearly produces organic effects, does not cause the loss of the function put into action by the excitation.

These views are probably correct, in the main, although they may receive some modification with increase of knowledge upon this subject. Regions of the brain in the process of evolution have been differentiated into definitely localized centres of representation in pro-

portion as the functions represented have become more and more volitional, more and more under the control of the individual. We can never probably have localizations for organic manifestations which will be available, for instance, for the purposes of the surgeon. A closer and fuller study may show the truth to be largely the same even for the so-called thermic or heat centres. It is altogether doubtful whether we have distinct vaso-motor cortical centres comparable to the simple centres for motion. In reference to this question, Franck says that all localizations of this kind ought to be renounced. The cortical surface, he says, agrees in a certain degree with the sensory surface, and does not contain the vaso-motor centres any more than the organic centres, whatever they may be ; the cortex fills the roll of separation, and not that of a productive organ of visceral reactions. The true vaso-motor centres are contained in the bulb and spinal cord. They receive the cerebral excitations as they receive the peripheral excitations, and react in both cases in a reflex manner in consequence of a similar mechanism.

Such localizations as those of Christiani* of higher respiratory centres must not be regarded in the same light as motor, visual and other independent simple localizations. This investigator, as the result of a series of experiments on rabbits and dogs, believed that he had found higher respiratory centres, three in the basal ganglia ; first an inspiratory one, chiefly reflex, at the bottom of the third ventricle ; second, one, also inspiratory, at a point between the anterior and posterior corpora quadrigemina ; third, an inspiratory and inhibitory centre at the entrance to the aqueduct of Sylvius. He also discovered, anterior to the inspiratory centre in the third ventricle, a coördination centre.

To speak of emotional centres in the same sense that we do of motor, visual, or auditory centres, is also unphilosophical. In certain organic brain lesions, says Pontoppidan,† emotional manifestations such as laughing or crying appear without a cause ; or an emotional cause produces undue effects, a pain, for instance, produces laughter. Such symptoms are usually met with in disease of the pons and oblongata. The investigations of Pontoppidan seem to show that the centres affected in such cases are those in the vicinity of the vaso-motor centre in the pons. He describes in detail three such cases. In the first, any question caused the patient to laugh ; in the second, laughing or crying occurred indiscriminately when any attempt at conversation was made by the patient; in the third, fits of laughter occurred without any apparent cause—the mere entrance of any one into the room would

* 36 DuBois Arch., 1884.

† Centr. f. Nervenheilk., 1887.

produce one. In two of these cases autopsies showed the existence of apoplectic clots in the crus cerebri and pons Varolii, and other symptoms of pons disease were present.

In the nervous wards of the Philadelphia Hospital are several cases similar to those described by Pontoppidan, other symptoms pointing also to disease of the pons. Such facts, however, do not indicate the existence of a special centre for emotion, comparable in any true sense to the circumscribed centres of the cerebral cortex; but rather point to the fact that in the pons-oblongata we have crossing and interblending the various tracts, ascending, descending and transverse, which unite the higher regions of the nervous systems to those lower centres which energize the nerves and muscles concerned in the expression of emotion, or join together these lower centres and the cerebellar hemispheres.

Cerebral Localization in its Relations to Surgery.

Let me now turn to the surgical aspect of this great subject—the surgical aspect in so far as it concerns the neurologist; it is upon this that the attention of the medical world is riveted to-day.

In this portion of my remarks, I will consider (1) the forms of disease and injury in which cerebral localization is a valuable aid to diagnosis; (2) the parts of the brain accessible to surgical interference, and the topographical diagnosis for these accessible areas, with some sources of error in diagnosis.

The neurologist is now constantly called upon with the surgeon for the relief of intra-cranial affections long held not to be amenable to treatment, and scarcely worthy, from a practical point of view, of diagnosis. My remarks must be chiefly concerned with questions of diagnosis.

Examination of medical literature shows that operations upon the brain, guided by localization, have been for tumor, cyst, fracture, abscess, hemorrhage, and discharging cortical areas.

Brain Tumors.

It may be broadly affirmed that brain tumors should be removed by operation when their exact position can be diagnosticated, when they are in accessible areas, when they are solitary, and when they are not of enormous size. Of Dr. Park's 63 cases, 11 are cases of tumor, and 12 of cyst; of 17 operations by American surgeons, 5 have been for tumor. In this connection I will only stop to give some facts and draw some inferences from personal experience; it is often wise to review personal experience

even if in so doing we sometimes awaken vain regrets. I have notes of 20 cases of brain tumor with autopsies, most of which have already been published in some form. Hale White's* cases numbered 100; and Seguin and Weir,† combining the statistics of White and Bernhardt, tabulated 580 cases. Twenty cases are comparatively few, but such a list has the advantage of thorough personal knowledge. Of these 20 cases the locations were as follows: Prefrontal lobe, 2 cases; posterior portion of second frontal gyre, 1 case; motor (Rolandic) zone, 6 cases; superior parietal lobule, 1 case; temporal lobe, 2 cases; cerebellum, 2 cases; mid-base and corpus callosum, 1 case; pons-oblongata, 4 cases; optic thalamus, 1 case.

Twelve out of the 20 cases were in areas accessible to operation; one of the accessible cases was multiple. Of the 11 accessible cases left, 4 were fibromata, 3 gummata, 2 tubercular, 1 a carcinoma, 1 a glioma with intercurrent hemorrhage. In neither of the 2 tubercular cases would operation have been successful because of the diffusion of cerebral tubercular disease. The carcinoma and glioma would probably have given only temporary success. Of the 7 cases left, all could probably have been removed successfully by operation at some stage of their growth; although in 3 of the cases, at the time of death, the tumors were of such size, and the break-down of brain-tissue in their neighborhood was so great, that the operation then would probably not have resulted in success. In at least 4 of the 20 cases, operation at any time before death would, in all probability, have been wholly successful. Is it any wonder that vain regrets for lost opportunities sometimes arise?

I favor the removal of old gummata, and this opinion is based upon considerable experience. Again and again I have seen such growths resist the most active and persistent anti-syphilitic treatment. It is probable that one reason why they will sometimes not yield to medicinal means is because in the progress of their growth they have obliterated blood vessels and become practically inert foreign bodies. Bergmann and White oppose, and Seguin favors the removal of gummata.

Cranial Fractures.

Localization rules are sometimes of value, even in cases of visible and easily detectable fractures, with lacerations, scars, clefts, depressions or ridges. These rules may be called in to clear up obscure points. Often in cranial fractures the extent of unseen damage cannot be told

* Guy's Hosp., 1884–85, 3 S., xxviii.

† Am. Jour. Med. Sci., July, August and September, 1888.

by the position and character of visible lesions. Numerous cases have been reported in which the operators would have been misled by trusting to external evidences alone; but in which by calling in the established facts of localization to assist they were able to place the trephine over the best spot for operation. Examination of surgical literature also shows that in many cases, demonstrated by autopsies, if the rules of localization had been properly applied, the site of hidden fractures either of the internal table or not, could have been determined and operations performed to the great benefit of the patient.

The best point for trephining in cases of fracture is not always the place of the greatest depression or cleavage, or over the centre of a large scar. In fracture cases the symptoms of dural irritation will often be prominent, and, particularly when the injury is over the motor area, may confuse the picture of spasm which is presented. The spasm may be dural or reflex, rather than cortical, or may have a mixture of reflex and cortical characteristics; and hence may be on the same side as the lesion or general, and thus involve the mind of the diagnostician in some doubt. An abscess resulting primarily or secondarily from a fracture may be so situated, or may have so enlarged, that localization rules alone can determine the best site for trephining. According to Jacobson,* out of 70 cases of middle meningeal hemorrhage a fracture was present in 62; so that in the majority of instances both fracture and hemorrhage must be taken into account.

Intra-cranial Abscess.

The question of intra-cranial abscess as well as fracture will be fully treated by Dr. Park and I will therefore say but little about these subjects. The cases of abscess in which localization rules have given the most brilliant results have been those in which without external evidences, a position for operation has been fixed. Several brilliant operations guided by cerebral localization have been recently reported, one of the most striking of these by Ferrier and Horsley.† This patient first complained of pain in the left ear, later a discharge, first clear and then of blood occurred. He became stuporous, had pain in the left side of the head, forehead, and back of the eyes, and photophobia. Later he became delirious and showed relative weakness of the right side of the face, a peculiar form of aphasia, and slight paresis of the right upper limb especially of the hand and digits. He had well marked optic neuritis, with a small hemorrhage over the right disc, and a small band below that of the

* Guy's Hosp. Rep., 1884–85, 3 S., xxviii, 147–308.

† Brit. Med. Jour., March 10, and March 24, 1888.

left. His speech disturbance was peculiar. He was able to sit up in bed and talk, but his words were incoherent and for the most part unintelligible. He appeared to understand simple questions, but at other times seemed confused and unable to understand. He called things by wrong names. When asked to read a few sentences from a journal, the words he uttered had little or no resemblance to those before him. In addition to the involvment of the auditory centres there was probably here also a fracture between the receptive and emissive speech regions. Mr. Horsley operated for the locality determined by Dr. Ferrier and himself; about five drachms of pus were removed and the patient recovered. Dr. Ferrier refers to other operations reported by Gowers and Barker, Greenfield, Schondorff, and Truckenbrod, the first two having been cases of abscess in the temporal lobe diagnosticated without external indications.

Intra-cranial Hemorrhage.

In a large number of cases of intra-cranial hemorrhage trephining has been performed, successfully or unsuccessfully. I have collected many of these cases, but cannot refer to them here except in the most general way; they constitute in themselves material for a lengthy paper. During recent years some important operations for such cases of hemorrhage have been guided by the principles of cerebral localization. Dr. J. B. Roberts, of Philadelphia, in his monograph on The Field and Limitation of the Operative Surgery of the Human Brain, of American authors has most thoroughly discussed the questions of operative interference in these cases of intra-cranial hemorrhage, as well as in fractures, abscess, tumors, and other lesions.

Intra-cranial hemorrhage may be (1) supra-dural; (2) sub-dural; (3) cortical or sub-pial; (4) intra-cerebral, that is, into the basal ganglia, capsules, or both, or into the centrum ovale. The first two forms are commonly due to lesions of the meningeal arteries, chiefly the middle meningeal, and are frequently associated with fracture, and occur from injury. Cortical or sub-cortical hemorrhage has its source in the cerebral arteries proper, most frequently in the cortical system of the middle cerebral.

These cerebral arteries have also a central or ganglionic system of branches, independent of the cortical, and it is from this arterial network that the ganglionic or capsular hemorrhage occurs. Hemorrhage into the centrum ovale may occur from the terminal vessels of either the cortical or ganglionic system.

Hemorrhage from contre-coup often calls for the application of the principles of localization. In cases of contre-coup the lesion, however, is often a form of bruising of the brain and its membranes with but little hemorrhage, for which trephining would be of no especial service, and it is important to distinguish such cases from those in which a genuine hemorrhage is present.

The forms of hemorrhage most amenable to topographical diagnosis and operative procedure are from the meningeal arteries proper and from the cortical system, that is, supra-dural, sub-dural and cortical. True cortical hemorrhage is comparatively rare, and meningeal hemorrhage comparatively frequent. Sometimes, instead of coming directly from a meningeal artery, the bleeding may be from the diploe of the fractured skull.

According to Kronlein,* the most frequent site of intra-cranial hæmatoma is the middle fossa of the skull, such lesion being usually limited in front by the lesser wing of the sphenoid, and behind by the margin of the petrous portion of the temporal bone, because of the adherence of the dura mater at these places ; below they reach nearly to the foramen spinosum, and above to the squamous suture, sometimes crossing the latter. The effusion is always thickest at the site of the rupture.

The symptoms of middle meningeal hemorrhage and supra-dural clot are both general and localizing. The general symptoms are such as loss of consciousness, and, in cases of traumatism, an interval of consciousness before the appearance of pressure symptoms ; change in temperature, usually elevation ; somnolence, stupor or coma ; slow pulse, sometimes becoming frequent at last ; slow, labored respiration ; vomiting. A small hemorrhage may give rise to few, if any, serious general symptoms.

Supra-dural Hemorrhage.

The symptoms of extravasation, when the hemorrhage is supra-dural are chiefly general. Contra-lateral paralysis, however, when the bleeding is over the motor area, may serve as a broad localizing indication when external appearances are wanting. Certain other phenomena are also usually present.

Unilateral affection of the pupil is often a sign of the utmost importance, particularly if, says Jacobson, one pupil is found widely dilated, the other being natural or contracted in size, and if the dilatation be on the side of the face corresponding to the injured side of the head. Mr. Jonathan Hutchinson has particularly studied and discussed

* Quoted by Jacobson.

the importance of this valuable symptom, and in honor of him Jacobson proposes to call it the "Hutchinson pupil." Hutchinson regards the symptom as due to direct or indirect compression of the third nerve. The pupils also furnish valuable indications as to the probability of recovery. The more dilated, insensitive and immovable they are, the less favorable the prognosis.*

Of the many cases of supra-dural extravasation which have been reported, in very few have the symptoms been studied closely.

Sub-dural Hemorrhage.

Sub-dural, or intermeningeal hemorrhage, if extensive, gives general symptoms much like those which are present in supra-dural clot, namely, loss of consciousness, changes in temperature, pulse and respiration, vomiting, etc. A sub-dural clot will usually to a greater or less extent bruise, and possibly even tear the brain surface. Spasm due to irritation of the motor cortex may be present, as well as dural or reflex spasm. Paralytic symptoms will be definite and pronounced if the lesion is in the motor region. Cheyne-Stokes breathing may or may not be present. The following are condensed notes of three out of a number of cases of this kind, of which I have collected the histories.

The first is a case of unilateral meningeal hemorrhage with contra-lateral symptoms, reported by S. N. Townsend Porter.† The patient was a woman admitted to the hospital unconscious, with Cheyne-Stokes respiration, which became stertorous and puffing. Paresis of arm and leg on left side, mouth slightly drawn to the right side, and left naso-labial fold almost obliterated.

* Recently I had the opportunity of seeing an instructive case of supra-dural clot in the Philadelphia Hospital, in the wards of my colleague, Dr. F. X. Dercum. I will only refer to the case briefly, as it will doubtless be more fully reported by Dr. Dercum. The patient was a plethoric young man who came into the hospital without history, having been found in a stable insensible. Temperature, 95° F.; respiration stertorous —in breathing only the right nostril dilated and the right side of the mouth puffed; pulse weak, intermittent. The patient was insensitive to all impressions. Both arms and legs were spastic; the former drawn upwards and across the chest; the latter extended, the feet turned somewhat inwards. Occasionally jerking movements of both arms occurred. The head turned toward the right; the right pupil was dilated and dilating while the patient was under my observation; there was also right external strabismus. The patient died a few hours after these observations were made. The autopsy showed a bruised appearance of the skin about an inch above and to the right of the occipital protuberance. No depressed fracture was present, but a slight cleavage of the external table of the skull, and an extensive radiating or stellate fracture of the inner table. An immense supra-dural clot was found covering the lateral aspect of the parietal, and largely of the occipital lobe. The clot was back of the motor area.

† St. Louis Med. and Surg. Jour., 1887, vol. lii., p. 76–78.

Only moved the right extremities ; the head turned toward the right. Feeble convulsion lasting three minutes at night. Both sides affected, but left much less so than the right. Next day head and right eye showed marked deviation to right side. A clot was found between dura and pia weighing 170 gmms ($5\frac{3}{10}$ ozs.). It covered almost the entire right hemisphere. Gyri of right side were slightly flattened and of pinkish hue. Puncta vasculosa marked. The ruptured vessel not found.

The second is a case of inter-meningeal hemorrhage with general symptoms, reported by Clemen.* Female, 67 years. Intense headache, chiefly frontal ; worse from 8 to 10 P. M. At times wakeful and restless for days together, and then would become drowsy and semi-unconscious. No motor paralysis ; incontinence of urine : general hyperæsthesia ; cerebral breathing at times ; sometimes twitchings of flexors and pronators of both forearms. Old bloody intra-meningeal effusion was found between dura and arachnoid, over both hemispheres, extending into the middle posterior fossæ of the skull on the right side ; only in the middle fossa on left side the clot was thickest in convexity. Also some adhesive meningitis, supposed to have been due to slow simultaneous multiple capillary hemorrhage.

Dunn† has recorded the details of a case of clot over the motor area causing rhythmical motions of the other side of the body. The patient was a female 73 years old. Congestive apoplexy. (?) Fair recovery in a few days. Second attack during the night. Regularly recurring rhythmical movements of the left side of the body. Sensation and consciousness were normal. The right side of the body could be moved at will. Articulation impossible. Incontinence of urine and fæces. The movements of the body continued during sleep, and gradually lessened, leaving the leg on the fourth day and arm on the fifth. A clot as big as a hen's egg was present on the right side of the brain : this was superficial, reaching from the pre-central gyrus to the occipito-parietal fissure, and from the longitudinal fissure to the temporo-sphenoidal lobe.

Cortical Hemorrhage.

Sub-dural or inter-meningeal hemorrhages are frequently also cortical, that is, they invade or involve the pia-arachnoid and cortex. Occasionally, however, cases of intra-cranial hemorrhage occur which may be more particularly classed as cortical or sub-pial. These are usually limited in size, and often take place from arterioles or capillaries. A case reported by Horsely ‡ illustrates what is meant by one of the forms of true cortical hemorrhage.

This was the case of a man who had been suffering from tubercular disease of the bone for some months, and suddenly developed symptoms of thrombosis of the longitudinal sinus with cortical epilepsy as the result. The case is interesting not only as one of a peculiar form of cerebral hemorrhage, but also because of its teachings with reference to the area for the turning

* Medical Press and Circular, 1886, vol. i., p. 335–336.

† Jour. of Am. Med. Ass., 1886, vol. ii., p. 75–76. ‡ Brain, April, 1888.

of the head and eyes to the opposite side, and, at the same time, the anterior limit of the upper limb area, together with the special representation of the segments of that limb at the anterior part of the region devoted to it. "The movements observed were first turning of the head to the left; then raising the arm at right angles to the trunk in complete extension, with extreme extension of the wrist and interosseal position of the fingers; gradual turning of the head to the right, and subsequently the rest of the body involved in the spasm."

Thrombosis of the sinus and veins was present and caused the following lesions. "*Right hemisphere.*—The surface of the hemisphere appeared perfectly normal, except in the neighborhood of the blocked frontal vein before described. The posterior sixth of the middle frontal convolution in its whole breadth was the seat of a hemorrhagic extravasation. The ascending frontal convolution was highly congested, especially in its anterior border; the membranes also of the superior frontal sulcus were congested along its posterior third, and there was a slight hemorrhagic extravasation in the outer border of the middle third and the superior frontal convolution of this side (the right). *Left hemisphere.*—There was a dark black hemorrhagic focus occupying the anterior half of the middle third of the superior frontal convolution for half its breadth. This, the only lesion in the left hemisphere, was situated at the highest point of the area for the head and neck in the left hemisphere."

Small, superficial, cortical extravasations of this kind are to be localized by the rules and principles for irritative and destructive lesions of the brain surface of whatever character.

Intra-cerebral Hemorrhage.

Intra-cerebral hemorrhage will next engage our attention. Of course a hemorrhage may take place anywhere within the cerebrum—in the pre-frontal, postero-frontal, parietal, occipital or temporal lobe, but we cannot stop here to differentiate between the varieties of hemorrhages occurring in these positions. The remarks upon the localization of lesions of any kind in these locations will in large part apply to hemorrhage. In this connection the discussion will be largely confined to those varieties of intra-cerebral hemorrhage which are most common, and which might be said to have become almost classical—the cases of hemorrhage into or near the great ganglionic masses.

Commonly intra-cerebral hemorrhage occurs, as Gendrin and Charcot * have pointed out, not in the body of either the caudate or lenticular nucleus, but rather just in contact with the external surface of the lenticular ganglion. Not infrequently small hemorrhages occur in these positions. When a large hemorrhage occurs, it forces its way

* To Charcot we are indebted for our most exact knowledge of this branch of the subject of localization.

especially in a transverse direction, tearing through and pressing aside the brain substance, the greatest compression taking place towards the lateral ventricle because the resistance is least in this direction. Symptoms of both destruction and pressure abound in such cases and are sometimes hard to separate. Sometimes the hemorrhage breaks through the ganglia and the internal capsule and inundates the ventricles.

The central branches of the middle cerebral artery play the most important role in such hemorrhages. Charcot * has indeed proposed to call one of the branches of this middle cerebral artery "the artery of cerebral hemorrhage." This vessel after having entered the third segment of the lenticular nucleus traverses the superior portion of the interior capsule and then enters the body of the caudate ganglion. In rare cases the surgeon might trephine successfully for intra-encephalic hemorrhage. This must be done, if at all, at a point where it has been determined by pathological observation that the hemorrhage in its enlarging waves outwards usually comes nearest the surface, or would be most easily reached and relieved. The cases of hemorrhage in which the ventricles are broken into and inundated would probably be benefited only very rarely by operation, but no harm could be done in such an almost necessarily fatal case.

Intra-cerebral hemorrhage may occur in any one of half a dozen positions with reference to the three great ganglia at the base of the brain, and the internal or external capsule. With our present knowledge the exact position of some of these hemorrhages cannot from any localizing data be accurately determined. It remains true now, as stated by Charcot ten years ago, that lesions confined to any one of the gray central ganglia when the internal capsule is not involved, do not give any special diagnostic features. We have no characteristic symptoms based upon a knowledge of the functions of these ganglia. Certainly a hemorrhage or other lesion cannot yet be very positively determined as limited to either the caudate or lenticular body or the thalamus.

With reference to hemorrhage without ventricular inundation several locations in or near the ganglia may be diagnosticated If the hemorrhage has occurred at a position corresponding to the anterior half, or perhaps two-thirds of the lenticular ganglion and internal capsule, the chief effect is the production of motor paralysis of the opposite half of the body with symptoms of the acute apoplectic attack, which symptoms are practically the same for all

* Lectures on Localization in Diseases of the Brain. Translated by Edward P. Fowler, M.D., New York, 1878, p. 73.

the non-ventricular varieties. If the hemorrhage has occurred so as to be related to the posterior third of the capsule, where it lies chiefly between the lenticular body and the thalamus, paralysis both of motion and sensation of the opposite side of the body will be the great feature. When the extreme posterior limit of the internal capsule and ganglia are the seat of extravasation, contralateral hemianæsthesia without hemiplegia will be present; but this variety is comparatively rare. Many facts with regard to the regional diagnosis of such hemorrhages have been given by Charcot. It does not come within the purpose of my paper to discuss the exact arteries affected, and various other collateral matters anatomical and pathological, but I wish simply to give the persisting diagnosticating features of these forms of hemorrhage; and the symptoms usually observed at the time of the apoplexy. The latter are loss of consciousness, more or less complete according to the extent of the hemorrhage; stertorous respiration, sometimes so far as the mouth is concerned, one-sided; sometimes also Cheyne-Stokes; temperature at first lowered and afterwards rising; pulse sometimes slow and full, sometimes weak and intermittent. Conjugate deviation of the head and eyes may be present but is not invariable; it is usually away from the side of the paralysis. It is not infrequently somewhat difficult to determine the full extent and character of the paralysis and loss of sensation, if this also be present, in these cases of apoplexy. Careful inspection of the face, however, will usually show some drooping on the side of the paralysis and some pulling to the other side. Watching the limbs, the unparalyzed members will be seen to be used by the patient occasionally. The paralyzed extremities when taken hold of are usually limp and offer no resistance, while a certain amount of resistance is offered by the limbs of the other side even though the patient may be unconscious. My experience has shown me that cases of even somewhat extensive extravasation into the capsules and ganglia, differ considerably in the amount of paralysis produced. A fuller knowledge of intra-cerebral localization may eventually throw light upon these differences. In general terms the paralysis of the limbs is usually much more complete than in cases of cortical lesion.

The following notes of a recent case of intra-cerebral hemorrhage restricted to the internal capsule and ganglia will serve to illustrate one of the forms of hemorrhage. The patient, a man 62 years old, was admitted to the Hospital in a nearly unconscious condition. When first admitted he had some use of all his limbs; but he gradually became worse and in the course of twelve hours could not respond intelligibly to anything that was said to him, but even then he could be aroused so that he would open his eyes and look

around for a few moments, and then sink again into a stupor. When able to speak his articulation was thick and indistinct. For at least twelve hours he certainly understood what was said to him. His breathing was puffing and gradually became more stertorous. It never assumed the true Cheyne-Stokes type, but showed an occasional tendency to do this. After he had become totally unconscious a few conditions were positively determined. The mouth was drawn slightly but distinctly to the left; his right arm was paretic; the right leg was helpless and spastic. The left leg also remained nearly all the time as if powerless, and it was difficult to determine any difference as to loss of power of the two extremities. He had not true conjugate deviation of the head and eyes, although his head at times showed a tendency to turn to the right. The pupils were equal and slightly dilated. Knee-jerk was present and marked on the right, diminished on the left. His head temperature, taken once at a spot corresponding to a point just below the middle of the horizontal branch of the Sylvian fissure, was 96.2° on the left, and 100.4 on the right. The patient lived six days from the time of his admission. His body temperature when first taken was 96°. It rose the second day to 101°, and from that time on until his death, ranged between 99° and 102°, being at the highest point at the time of death. He developed pneumonic symptoms three days after admission.

At the autopsy, on exposing the left lateral ventricle a nearly black, irregularly shaped spot was seen reaching across the caudate nucleus where it begins to curve around the thalamus. This appearance indicated a recent clot which had not quite broken into the ventricle, still having a thin roof formed by a layer of the caudate body. The ganglia and capsules were studied by transverse sections. The anterior limit of the extravasation was towards the median line of the brain, and was three-fourths of an inch from the head of the ganglia. Its posterior limit, a narrow wedge, was one-third of an inch in front of the posterior extremity of the thalamus. The blood was still fluid, and the parts involved by the clot were chiefly the middle portions of the lenticular body and internal capsule, and an external anterior segment of the thalamus. The pia mater of the convexity was œdematous and opaque, in spots and patches hyperæmic, and Pacchyonian granulations were exuberant. The blood vessels were highly atheromous. The kidneys showed interstitial nephritis. One lung was nearly solidified, and a patch of consolidation the size of a lemon was found in the other.

In this case the hemorrhage probably occurred slowly and most likely at the site of an old cyst. In cases of rapid hemorrhage in the same locality, all the general symptoms such as loss of consciousness, changes in respiration, temperature, etc., would be more sudden and complete. If breaking into the ventricles should occur it would become more profound and threatening.

In this case, as in others, I made some experiments to determine whether the extravasation could have been reached by trephining. A needle or trocar passed through the upper portion of the third tem-

poral convolution, or at the line of junction of the second and third, about 3 inches back of the anterior extremity of the temporal lobe, in a direction forward and downward reached the clot at a distance of about an inch from the surface. It would be necessary if trephining was attempted to thus enter the temporal lobe, low down and well back so as to avoid the Sylvian fossa and island of Reil. In a highly vascular territory like the Sylvian fossa the cortical vessels are large and near their origin from the middle cerebral and internal carotid arteries, and if in operating this fossa was carelessly penetrated, more harm than good might be done to the patient. The peculiar position in which the ganglia and capsules are located with reference to the Sylvian fossa, the island, and the descending horn of the ventricles, would constitute one of the chief sources of difficulty in attempting to trephine for intra-cerebral hemorrhage. Still the operation is not impossible, and we will probably eventually learn exactly how far it can be resorted to with advantage, probably only in a very limited number of well chosen cases.

Intra-cerebral Hemorrhage with Inundation of the Ventricles.

What now are the symptoms of intra-encephalic hemorrhage with ventricular inundation? Whether this form of hemorrhage is or is not susceptible of improvement by operative interference, its diagnosis has considerable negative practical importance. I have, for instance, known the diagnostic question chiefly discussed in an important case to have been, whether the patient was suffering from a hemorrhage which had burst into the ventricles, or from supra-dural or sub-dural clot of immense size. Certainly as I have seen the cases there are striking points of resemblance between some cases of ventricular and some of meningeal hemorrhage; but the points of difference are sufficient to separate the varieties if we are sufficiently careful and minute in our study.

In the Philadelphia Medical Times, for October 23, 1880, I published a history of an interesting case of hemorrhage into the basal ganglia followed by effusion of blood into and beyond the ventricles, and I have studied and made autopsies upon other similar cases. In the case reported, the patient, a man 63 years old, while eating his dinner suddenly fell unconscious; his breathing became puffing, and marked right-sided paralysis was at once observed. The right arm and leg were powerless, and inspection showed that both the upper and lower muscles of the face were paralyzed. The right eye remained partly open and the mouth was pulled decidedly to the left. Two hours after the attack it was noted that he was profoundly unconscious; his face was pale; the right eyelids did not quite close; the pupils were sluggish

but equal, the eyes were directed straight forward; conjunctival reflex was present: the mouth was drawn slightly to the left; the right nostril was more dilated than the left; no sensory responses could be obtained; the skin reflexes were marked and somewhat exaggerated on the left side of the body, the triceps reflexes were well marked but the knee-jerk was not examined. General inspection showed but little difference in paralysis between the limbs of the right and left side; but closer examination revealed a more profound paralysis of the right than of the left limbs; he occasionally moved the left arm and leg, and a tendency to contracture was present on the right side. Tremulous and spasmodic movements occurred on both sides of the body, but were a little more marked on the right than on the left. The pulse on the left side was comparatively full and strong; on the left feeble, frequent, and irregular. The temperature was taken several times in both axillæ, and varied between 99° and 101.2°, but with no uniformity as to the two sides. A marked difference between the head temperature of the two sides was noted, the right Rolandic station giving temperature of 102, the left only 99.2. The breathing passed through three periods, at first it was puffing, soon Cheyne-Stokes, and two hours before death regular but constantly feebler and shallower. When of the Cheyne-Stokes type, the period of nearly regular breathing lasted from four to five minutes, the apnœal stage only from eight to fifteen seconds. When breathing began after the apnœa it presented an ascending character, but the apnœal stage began very abruptly. He died about twelve hours after the stroke, and before death the paralysis of the limbs and face became absolutely general. The pupils became more dilated but not unequal.

Autopsy.—Resting the brain on its convex surface, large masses of dark blood could be seen occupying the central region of the base from the pons to the optic chiasm; the blood enveloped the cranial nerves in this area, and infiltrated the membranes and the spaces beneath them far out into the Sylvian fissure. Hemorrhagic foci were found here and there in the pia of the cerebellar hemispheres, the substance of which showed a few bloody points. The fourth ventricle was filled and distended with dark blood; its floor showed a very slight depression or splitting at the upper part; the aqueduct of Sylvius was very greatly dilated. The lateral ventricles which were entered from below, were filled with blood; their cornua were also enormously distended with blood. The septum lucidum, fornix, corpus callosum and commissures were broken down, and the lateral and third ventricles had become one cavity engorged with blood. The anterior extremity of the left optic thalamus and the cue-portion of the caudate nucleus were broken through. The hemorrhage had apparently taken place either from one of the lenticulo-optic or one of the posterior internal optic arteries.

Certain points of difference are to be noted between this case, and the previous one in which the hemorrhage did not reach the ventricles, as, for instance, the more sudden and profound unconsciousness, the complete unilateral paralysis which soon became general, the absence of all sensory response, the tremulous and spasmodic movements of both sides of the body, and the peculiar Cheyne-Stokes breathing.

I have examined the specimen from one case of secondary ventricular hemorrhage in which the primary extravasation took place in the centrum ovale of the parietal lobe, the blood breaking through the root of the ventricle ; but usually the secondary ventricular flooding takes place in the manner and from the direction indicated in the account of the case just given.

Of primary ventricular hemorrhage I have had no experience. "Primary ventricular hemorrhage," Gowers says, "causes symptoms which may, from the first, closely resemble those of the secondary form, but more frequently the onset resembles that of hemorrhage into the substance of the brain, in the presence at first of unilateral symptoms. Prodomata are rare, but headache is occasionally met with, very variable in seat, character, and duration. The onset may be (1) By sudden apoplexy, deepening rapidly ; death may occur in a few hours. (2) By apoplexy with hemiplegic symptoms, or with convulsions. (3) In the very rare slow hemorrhage, hemiplegia first occurs alone, loss of consciousness only supervening after a few hours. Hemiplegia occurs because the blood is effused into one lateral ventricle, and causes paralysis on the opposite side by the compression of the motor path or centres. When the effusion is rapid, and both lateral ventricles quickly become distended, the unilateral symptoms quickly give place to general relaxation of the muscles and loss of all reflex action. Rigidity is often met with, but less frequently than in the secondary form ; it is usually bilateral, sometimes one-sided, and occasionally involves only the muscles of mastication ; it is often intermittent. Convulsions are also frequent, occurring in at least a third of the cases, sometimes general, sometimes affecting only the paralyzed side, or only part of it. In cases of slow onset, speech is often lost before consciousness. The power of swallowing usually persists until the apoplexy becomes profound. The temperature resembles that of other forms of cerebral hemorrhage. The malady is usually fatal, but recovery has occurred, as is proved by old and altered clot being sometimes found in the lateral ventricles, but it is possible only when the hemorrhage is small in quantity and the symptoms are slight and equivocal." The fact that recovery has occurred in such a case is a reason for considering the practicabillty of trephining.

Tapping and draining the ventricles have been performed though rarely ; but in the future, with the comparative immunity from danger in our present methods of attacking the brain, may be resorted to much more frequently. The ventricles can be reached with pre-

cision at several points, best probably from an anatomical and surgical point of view, by way of the posterior horn, or perhaps where the lateral ventricle and the middle and posterior horns diverge. Besides blood, effusions into the ventricles may be also either serum or increased cerebro-spinal fluid, or pus from an abscess.*

Various practical questions arise in connection with the subject of trephining for intracerebral clots, particularly when deeply situated. It has been suggested that it might be impossible to remove the extravasation on account of its having formed a firm coagulum. It does not always do this. Within one week I saw two cases of intracencephalic hemorrhage, in one of which the cavity was filled with a firm clot and in the other the blood was entirely fluid although the patient had been dead more than twenty-four hours. Why this difference should occur I do not know, but it is a fact well known to surgeons that in hæmatocele, no matter where situated, when not in contact with the air, the blood is sometimes coagulated, and sometimes is not. Even though the blood has coagulated it might in some cases be removed by carefully enlarging the opening made by the knife to reach the seat of hemorrhage with flat retractors, and then extracting the coagulum in fragments with forceps or a spoon. The bleeding in case of cerebral hemorrhage is probably stopped because of the retraction of the vessel and the forming of a small coagulum in it, but of course the danger of producing a fresh or renewing an old hemorrhage should be considered. If such operations are resorted to, care should be taken not to move the patient more than is absolutely necessary.

* Since the meeting of the Congress Dr. W. W Keen, of Philadelphia, has proposed tapping and draining the ventricles as a definite surgical procedure, describing an operation for this purpose. He says: "As we now open the belly and drain in tubercular peritonitis with such remarkable success, I would propose that we do precisely the same for the brain. That it may be done with precision and without serious injury to the cerebral tissues the history of the present case, I think, abundantly shows; that it is even *more* urgently necessary in the brain than in the chest or belly seems clear when we consider the relative effects of pressure in the two cases. In the chest or belly the walls are more or less yielding or spongy, to a large extent. They can bear great and long continued pressure but with little damage to their ultimate integrity, or to life, if the pressure be relieved within any reasonable time.

Not so in the cranium. The walls are rigid bone, and the brain can undergo but little pressure, and for a brief time (except it be gradual, as in chronic hydrocephalus) without inviting death. The fatal issue is so uniform that *any* means that holds out a reasonable hope of relief, even though it involves great risk to life, should at least be tried; and the proposal in the present paper seems, at least, to involves but a moderate danger to life with a reasonable probability of success." (Medical News, December 1, 1888.)

Cortical Epilepsy without Gross Lesion.

In cases of cortical epilepsy when the symptoms indicate a discharging lesion of a localized cortical area, operation is justifiable whether or not the probability of a gross lesion can be made out. Hughlings Jackson in the course of a discussion of a paper on brain surgery, read by Mr. Horsely* at the meeting of the British Medical Association, at Brighton, in 1886, strongly advocated the cutting out of the part of the cortex which represented the peripheral parts first in the spasm, whenever the spasm began very locally and deliberately, and when the fits were often repeated. He advocated this, no matter in what condition the brain cortex might be found. He considered it quite certain that epileptiform seizures would be impossible in such a case if enough of the so-called motor area were removed. He believed it better to have some permanent paralysis than to be subject to fits, some becoming universal. This advice has already been acted upon by Horsley,† Keen,‡ Lloyd and Deaver,§ and Hearn and the writer. The most interesting case of the kind yet reported is that of Lloyd and Deaver. Macewen rather advises against this operation, particularly if large wedges of brain tissue are to be taken out, but I believe it to be good practice, even some permanent paresis being preferable to epileptic attacks with their destructive effects on the brain.

Accessible Areas of the Brain.

More and more has that region been narrowed which cannot be reached by the venturesome surgical explorer. The lateral aspect of the pre-frontal lobe, the entire motor area, the superior and inferior parietal lobules and the upper temporal region can, of course, be attacked with the greatest facility. In the regions difficult yet possible of access, lesions of large size and of displacing character will be more readily reached. The orbital surfaces of the pre-frontal lobe can be reached and large displacing lesions removed by trephining low down in the frontal bone. In Durante's case, the tumor removed occupied the left anterior fossa of the cranium. Almost the entire temporal lobe, with the exception of the parts bordering on the mid-brain is accessible. The occipital lobes have been operated upon successfully. With care the great median fissure may be entered for lesions of the marginal convolutions and limbic lobe. The longitudinal sinus has been successfully plugged and ligated. The

* Brit. Med. Jour., Lond., 1886, ii., 670–675.

† Ibid., Lond., 1887, i., 863–865.

‡ Am. Jour. Med. Sci., vol. xcvi., No. 4, Oct., 1888.

§ Ibid., vol. xcvi., No. 5, Nov., 1888

outskirts of the ganglia have been approached, and the ventricles have been pierced. Even a tumor situated on the intra-cranial portion of the auditory and facial nerves can probably be reached and removed. Suckling and Jordan,* Bennett May,† Horsley,‡ and Weir have looked during operation with the eyes of the flesh on the foramen magnum itself. Absolutely inviolable then are only the middle region of the base, and its bordering convolutions, the corpora quadrigemina, and pons-oblongata.

In the accessible areas of the brain are (1) regions in which an absolute localization can be made by positive symptoms ; and (2) regions in which a close approximate localization can be made by positive symptoms, combined with methods of exclusion and differentiation. Under the first head, come the motor, visual, and motor speech areas and tracts ; under the second, the cerebellum, the pre-frontal, and the temporal lobes, with their more or less positively determined functions. The areas for general sensation are still doubtful, but will be considered.

Motor Localization. Researches of Ferrier and of Horsley and Schäfer.

Motor localization has become almost an exact science. Properly interpreted, the phenomena produced by irritative and destructive lesions of the cortical motor area can be relied upon to lead the neurologist to a precise topographical diagnosis, with as much certainty as the stethoscope for cardiac diseases guides the thoracic diagnostician.

The latest physiological researches bearing upon this are those of Horsley and Schäfer.§ They give a new diagrammatic representation of the subdivisions of the motor area in the monkey, both upon the lateral and median aspects of the hemisphere, to which I call attention (Fig. 1 and 2). Excitation of the external surface of the hemisphere in the hands of these experimenters yielded results which were generally similar to those described by Ferrier, which they extended and confirmed, but with some extension as to detail. Comparison of these diagrams with the earlier diagrams of Ferrier, will show the direction in which recent experimentation has added to our precision in motor localization. (Fig. 3, 4 and 5).

In glancing at these more recent results in motor localization, I cannot refrain from paying a passing tribute to the enduring value of

* Lancet, October 1, 1887.
† Lancet, April 16, 1887, vol., i., p. 768.
‡ Brit. M. J., 1887, vol. i., 865.
§ Op. Cit.

the researches of Dr. Ferrier. Their accuracy and reliability are shown by the fact that the results obtained, even as to detail, have been in the main confirmed by the most careful later investigators. With reference to certain questions in dispute, as for instance, the situation of the area of representation of movement of the head and eyes in the second frontal convolution and adjoining regions the existence of distinct centres or areas for the senses of touch, pain, and temperature; and the relation of the so-called angular gyrus to vision, his positions have not been seriously disturbed; at the most, it has only been necessary to modify and enlarge his views, as, for example, to admit the part taken by the gyrus fornicatus in sensation, and of the occipital lobe in vision.

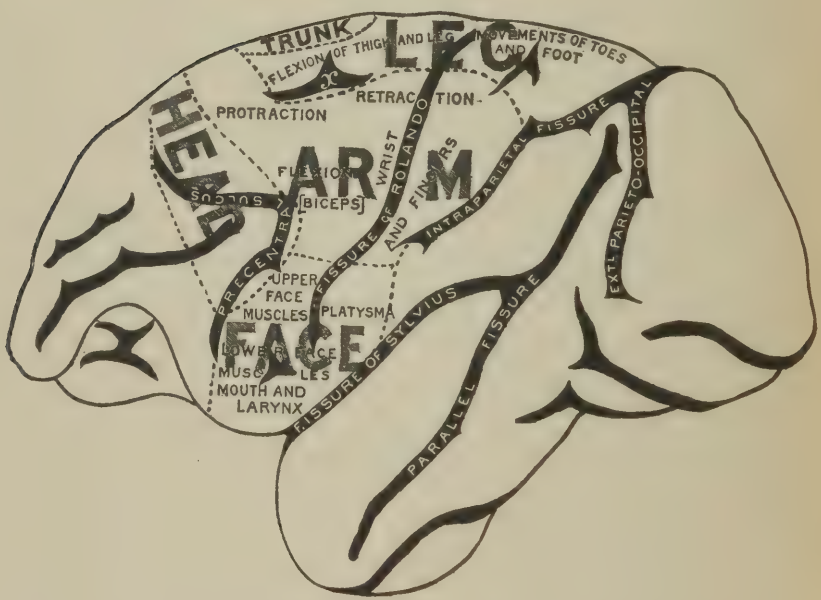

Fig. 1.—Lateral Surface of Brain of Monkey (Horsley and Schäfer).

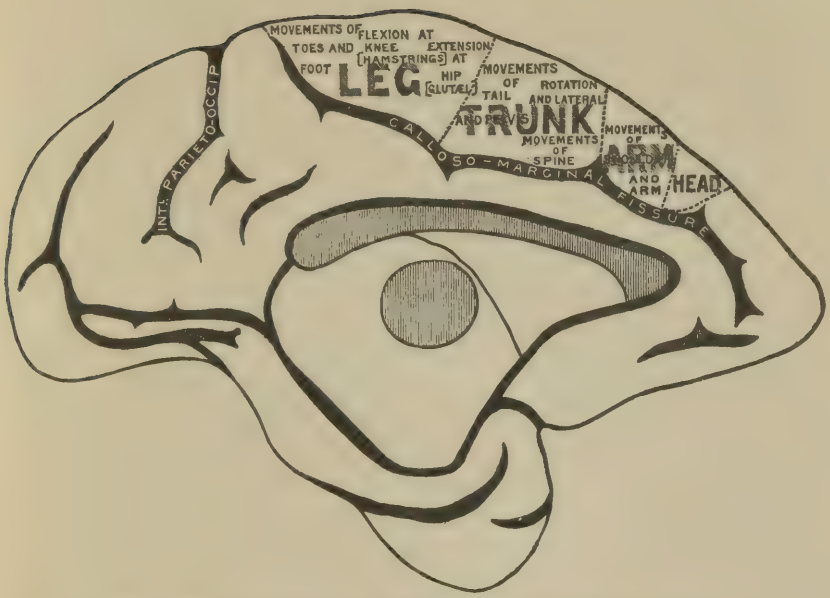

Fig. 2.—Median Surface of Brain of Monkey (Horsley and Schäfer).

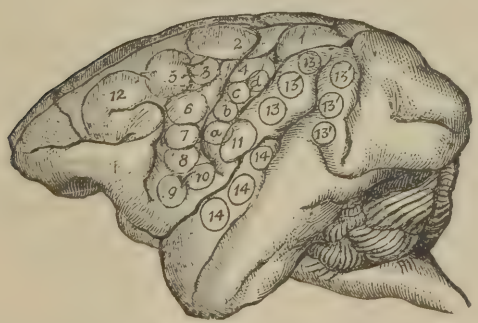

Fig. 3.—Lateral Surface of Brain of Monkey (Ferrier).

Fig. 4.—Lateral Surface of Human Brain (Ferrier).

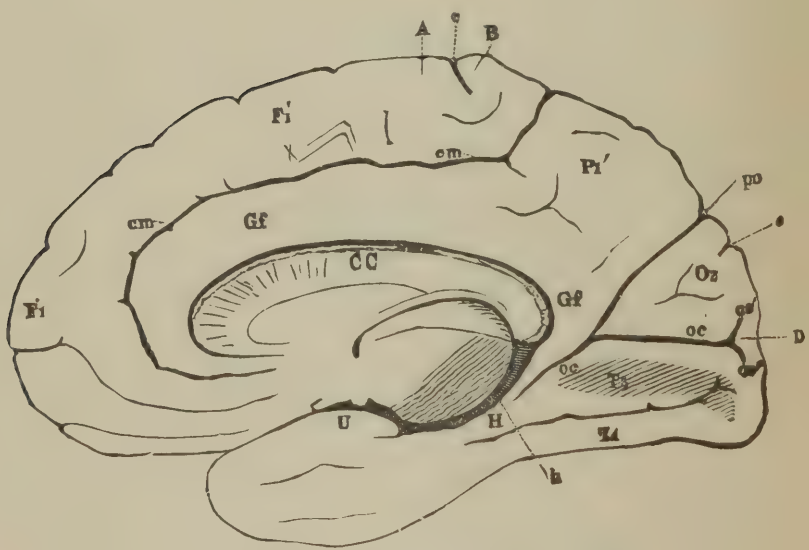

Fig. 5.—Median Surface of Human Brain (Ferrier).

On the diagrams of Horsley and Schäfer are placed the names of the zones and centres as determined by them. Below are given the explanations of the circles numbered on the diagrams of Ferrier representing both the monkey and the human brain. The numbering of the centres or areas is the same for both. The diagrams and descriptions are taken from Ferrier's treatise on the *Functions of the Brain.*

(1) placed on the posterior central and postero-parietal lobule, indicates the position of the centres for movements of the opposite leg and foot, such as are concerned in locomotion.

(2), (3), (4), placed together on the convolutions bounding the upper extremity of the fissures of Rolando, include centres for various complex movements of the legs and arms, such as are concerned in climbing, swimming, etc.

(5), situated at the posterior extremity of the superior frontal convolution, at its junction with the ascending frontal, is the centre for the extension forwards of the arm and hand, as in putting forth the hand to touch something in front.

(6), situated on the ascending frontal, just behind the upper end of the posterior extremity of the middle frontal convolution, is the centre for the movements of the hand and forearm, in which the biceps is particularly engaged, viz: supination of the hand and flexion of the forearm.

(7) and (8), centres for the elevators and depressors of the angle of the mouth respectively.

(9) and (10), included together in one, mark the centre for the movements of the lips and tongue, as in articulation. This is the region, Ferrier says, disease of which on the left side causes aphasia, and is generally known as Broca's convolution. (It will be seen later that I regard these as oro-lingual centres, but place another propositionizing speech centre in advance of this area.)

(11), the centre of the platysma, retraction of the angle of the mouth.

(12), a centre for lateral movements of the head and eyes, with elevation of the eyelids and dilatation of the pupil.

(a), (b), (c), (d), placed on the ascending parietal convolution, indicate the centres of movements of the fingers and wrists.

Circles (13) and (13), placed on the supra-marginal lobule and angular gyrus, indicate the centre of vision, which includes also the occipital lobe.

Circles (14), placed on the superior temporo-sphenoidal convolution, indicate the situation of the centre of hearing.

The centre of smell is situated in the uncus gyri hippocampi or hippocampal lobule. (Fig. 5, V.)

In close proximity, but not exactly defined as to limits, is the centre of taste.

The centre of touch is situated in the hippocampal region (Fig. 5, H) and gyrus fornicatus (Fig. 5, Gf).

Physiological Experiments on the Human Brain.

New clinico-pathological facts, obtained from surgical operations, and justifiable physiological experiments made upon the brain during

such operations, have all helped to more accurately fix the sub-areas of the motor zone. In a number of operations on the motor cortex, weak faradic currents have been used to accurately localize and define the centres sought. In four instances I have seen experiments of this kind, and in one had excision of the cortex performed through the indications thus offered. I have also had the opportunity of observing the effects of faradizing the white matter beneath the excised human cortex. Brief reports of such experiments occur in accounts of operations by Horsley, Keen, Weir and Seguin, Lloyd and Deaver, and others. Horsley first resorted to this means of diagnosis nearly five years ago. The neurologists are thus to some extent repaying in kind the gifts received from physiology. Such experimentation is not only justifiable, but sometimes demanded in the interest of the patient. Gentle faradization of the human cortex does no harm, although it is not so certain that this is true of the application of the galvanic current. The light thrown upon disputed questions by close repeated examinations made after operations will be referred to later.

Boundaries of the Motor Areas.

Let us now glance at the boundaries of the various motor areas—in front, behind, above, below. The anterior branch of the Sylvian fissure, extended mentally, may be regarded as defining the anterior limit of the motor area, including the centres for emissive speech and for the head and eyes. The area which represents the movements of the face is somewhat accurately limited in front by the precentral fissure ; but the movements of the upper extremity have their representation more forward of this line, as do also those of the lower extremity. In front, indeed, the region for the representation of the upper limb extends into the mid-frontal gyre for perhaps one-fourth of its antero-posterior extent ; blending in the anterior portion of this forward extension with the region for the head and eyes.

The inter-parietal (intra-parietal) fissure is usually regarded as forming the posterior limit of the motor area. This large fissure runs upward and backward across the parietal lobe. It is doubtful whether in man the whole of the superior parietal lobule or convolution is concerned with motion, and hence the so-called retro-central fissure is perhaps the more probable posterior boundary of the true motor region ; the postero-parietal area being concerned, in part, at least, with sensation.

This so-called retrocentral fissure (Fig. 6, Rc) is practically very constant in the human brain, and has been regarded by Wilder and others as a distinct sulcus. I have in a few instances seen it of nearly the

same length and depth as the central fissure itself. It is regarded by some as a secondary upward extension of the anterior extremity of the inter-parietal fissure. It generally runs parallel with the upper two-thirds of the central fissure, very clearly bounding behind the posterior central gyre. For practical purposes of operation, at least, this retro-central fissure may be regarded as the posterior boundary of the motor area, rather than the inter-parietal fissure as commonly described. This would leave a distinct postero-parietal region on the lateral surface of the brain in *man*, of uncertain function—a region included between the retro-central fissure in front and parieto-occipital behind.

The horizontal *branch* of the Sylvian fissure forms, as is well known, the inferior boundary of the motor region.

Until quite recently the longitudinal fissure or median edge of the hemisphere was generally regarded as the superior boundary of the motor area, but the investigations of Horsley and Schäfer have shown that this area extends over the edge of the hemisphere into the so-called marginal convolutions on the mesial aspect of the hemisphere, as represented in the diagram (Fig. 2).

As these results are not generally known, it might be well to quote from these authors their general conclusions as to motor representations in the marginal gyres.

"Looking, as a whole, at the results of stimulation of the excitable portion of the marginal gyrus," they say, "it would appear that the application of the electrodes at successive points from before backwards produces (1) movements of the head; (2) of the forearm and hand; (3) of the arm at the shoulder; (4) of the upper (dorsal) part of the trunk; (5) of the lower (pelvic) part of the trunk; (6) of the leg at the hip; (7) of the lower leg at the knee; (8) of the foot and toes." These movements, they say further, in a foot note, are the primary movements, but, as will be seen from previous descriptions, they are almost invariably complicated by secondary movements, which are usually the primary movements produced by excitation of the adjacent parts. The part of the marginal convolution which is concerned with the movements of the leg and foot is that portion which is often known as the para-central lobule.

Diagrams of the Areas and Sub-Areas of the Human Brain.

Based upon the investigations of Ferrier, Horsley and Schäfer, and others, and upon a study of cases, personal and collected from the literature of the subject, the diagrams (Fig. 6 and 7) have been made to approximately represent the areas and sub-areas or centres in the

motor zone. In addition, as far as possible, I have indicated areas or centres for other functions—speech, vision, hearing, etc.—so as not to necessitate the repetition of diagrams.

These diagrams (figs. 6 and 7) approximately indicate the views held by most localizationists, as the result of experiment and its confirmation or modification by clinico-pathological observation. They represent the division of the lateral and median surfaces of the cerebrum into higher psychical, motor, sensorial, visual, auditory, olfactory, and gustatory areas; also the subdivision of the motor area into sub-areas, for speech, the head and eyes, the face, arm, leg, and trunk: and the further subdivision of these sub-areas into centres for certain specialized movements of the face, arm and leg. The diagrams for the motor sub-areas are based upon the diagrams and researches of Horsley and Schäfer, but with some modifications as to extent and arrangement. Although a large portion of the paper immediately following is devoted to a consideration of the division and subdivision of the cortex into areas and centres of representation, it will probably serve a good practical purpose to give here immediately in connection with the diagrams a general description and explanation. Only certain main fissures have been indicated by lettering, so as not to confuse: *S*, fissure of Sylvius. *R*, fissure of Rolando or central fissure. *Pc*, pre-centralor vertical frontal fissure. *Rc*, retro-central fissure, sometimes regarded as a secondary branch of the inter-parietal. *F1*, first or superior frontal fissure. *F2*, second or inferior frontal fissure. *Cm*, calloso-marginal fissure. *Ip*, interparietal fissure. *Po*, parieto-occipital fissure. *T1*, first temporal or parallel fissure. *Ca*, (fig. 7) calcarine fissure.

The pre-frontal lobe, that portion of the brain anterior to the universally recognized motor region, has been designated as the higher psychical area. This term is certainly open to objection but it is difficult to substitute it by any appropriate general expression. All portions of the brain are concerned with processes of mentation, but this pre-frontal region, as Ferrier and others have shown, seems to be related to the highest mental processes, its lesions causing, when sufficiently extensive, a mental deterioration which is essentially or mainly a defect of the faculty of attention.

The motor area on the external surface of the hemisphere is made to include the posterior portions of the first, second, and third frontal, and both ascending or central convolutions, but not to reach backwards so as to take in the superior and inferior parietal convolutions. The sub-divisions of the motor zone into sub-areas and centres are indicated by the wording on the diagram, and are explained more at length in the body of the paper. Following Horsley and Schäfer's conclusion from physiological experiment the areas for the arm and for the head and eyes are made to extend forward and upward to the median edge of the hemisphere, but few if any clinico-pathological observations support this view, which is based upon physiological experiment and is probably correct. While, therefore, the portions of the first frontal convolution marked with asterisks * * may be regarded as theoretically included in the areas for the arm, and for the head and eyes, we are not justified for operative purposes in extending these areas above the first frontal fissure. No sub-divisions of the head, arm, trunk and leg areas in the marginal convolutions on the mesial surface of the hemisphere have been made in the diagrams, as these could only be so far our present knowl-

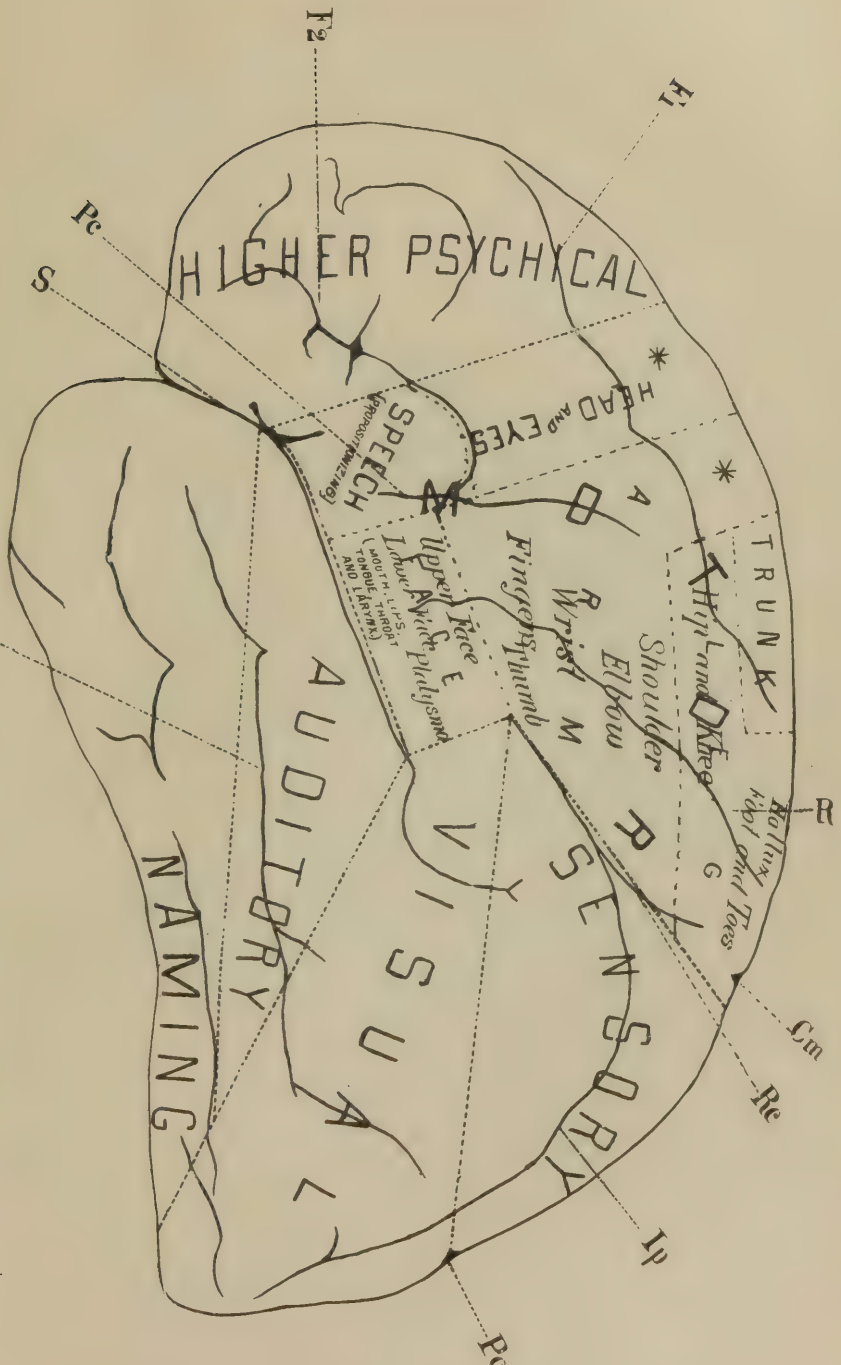

Fig. 6.—Areas of the Lateral Aspect of the Cerebrum, and Sub-divisions of the Motor Area.

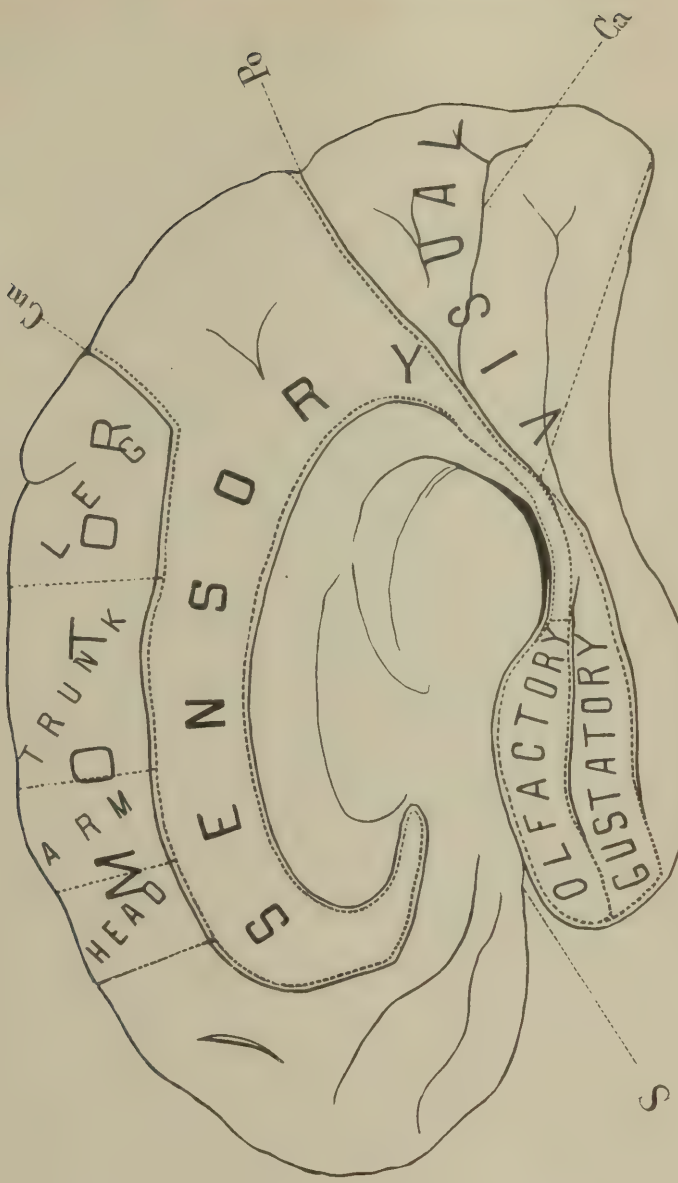

Fig. 7.—Areas of the Mesial Aspect of the Cerebrum.

edge goes, a reproduction of the subdivisions given by Horsley and Schäfer in their diagram (Fig. 2).

By the sensorial area is meant that for the senses of touch, pain and temperature, and modification of these senses, and it has been made to include the gyrus, fornicatus, hippocampal convolution, precuneus, and also portions of the superior and inferior parietal convolutions. This sensorial area has therefore been extended to the external surface of the cerebrum so as to include the general postero-parietal region. This keeps the motor and sensory areas distinct and is based upon the reports of cases with autopsies in which marked disturbances of sensation have been present, although experiments on the lower animals do not seem to have differentiated a sensory area in this lateral external region of the brain. The more elaborate development of the human brain in this region must not be lost sight of in considering this question. It is probable that the exact limitation of the area of common sensibility in the cerebrum has not yet been determined; but anatomical and morphological observations as well as clinico-pathological facts, point to the separation of this sensoral area from the motor region by the great calloso-marginal fissure on the median surface, and on the lateral aspect by it and the so-called retro-central fissure, *Rc*, the parieto-occipital fissure sharply demarcating it behind.

The visual area is represented in the two diagrams so as to take in all of the occipital lobe and adjoining portions of both the temporal and parietal lobes including the so-called angular gyre. Such a delimitation brings into fair accord the findings in reported autopsies, and the researches of Ferrier, Munk, Schäfer and others.

Auditory localization is still in an uncertain state, but limited pathological evidence favors localizing this faculty, as Ferrier advocates, in the first temporal convolution and probably also in the adjoining second temporal.

The views of Ferrier have been accepted as to olfactory and gustatory localization, according to which the centre for smell is located in the uncinate gyrus, and the sense of taste is closely related to that of smell, and may therefore be provisionally placed in the adjoining fourth temporal convolution. Possibly it is farther back in the temporal lobe than has been indicated in the diagram.

An area including the middle region of the temporal lobe—the third temporal convolution, and adjoining portions of the second and fourth has been designated provisionally as the ideational centre or region. This is in accordance with the views of Broadbent,* Kussmaul,† and some others. I believe the ground taken by these authors is a correct one. The only question in my mind is as to the exact localization of these centres for which they claim a dwelling place somewhere on the sensory, or receptive side of the nervous system. A consideration of the differentiation and localization of an ideational or conceptional area in the cortex comes up more particularly in discussion of disturbances of speech, and will doubtless be treated of fully by Dr. Starr, whose views may differ from mine. It is necessary, however, briefly at least, to discuss the question in attempting a division of the surface of the brain into general areas, and therefore I touch upon it in this connection. This region is, according to Kussmaul, that por-

* Brain, January 1879.

† Ziemssen's Cycl. Pract. Med., Am. ed., vol. xiv.

tion of the cellular net-work of the cortex in which ideas are produced as a result of impressions of the most varied description made on the senses (object-and-word-images). According to Broadbent also, the formation of an idea of any external object is the combination of the evidence respecting it received through all the senses; and for the employment of this idea in intellectual operations, it must be associated with and symbolized by name. The structural arrangement connected with this process he supposes to consist in the convergence from all the perceptive centres of tracts to a convolutional area which may be called the Idea Centre or Naming Centre. This, he believes, is on the sensory, afferent or upward side of the nervous system; its correlative motor centre being the propositionizing centre, in which names or nouns are set in a frame-work for outward expression, and in which a proposition is realized in consciousness or mentally rehearsed. The destruction of this centre among other things would cause the loss of the memory of names or nouns. As a provisional guess, Broadbent placed this centre in an unnamed lobule situated on the under surface of the temporo-sphenoidal lobe, near its junction with the occipital lobe, as he believed, fibres from all the convolutions in which perceptive centres have been placed by Ferrier, converged to and end in the cortex of this region. It would certainly seem probable that either in this middle temporo-occipital region, or in the insular or retro-insular convolutions, this conceptional, ideational, or naming region is located. Let no one be misled by this use of the terms ideational, conceptional, etc., and charge that it is an attempt to locate the mind in a limited region of the cerebrum. It is only an effort towards a more thorough understanding of the mechanism of thought and speech. A very careful study of the entire subject of speech disturbances, including an analysis of cases already reported, will, I think, be convincing as to the necessity of a higher area for speech and thought, intermediate between the sensory or receptive centres, and the motor or emissive.

From a study of these diagrams it will be seen that it might be practically convenient to sub-divide the brain into five lobes, four of these, at least, according to the great general functions subserved, these lobes having in nearly all directions well defined fissural boundaries. (1) A *higher psychical or inhibitory lobe*, in front of the basal and anterior branches of the great Sylvian fissure and on the median surface in front of the anterior bend of the calloso-marginal fissure. (2) A *motor lobe*, including the posterior parts of the first, second and third frontal, both ascending or central convolutions, and the adjoining marginal gyres on the median surface. (3) A *lobe for general or common sensation*, including the gyrus fornicatus, the hippocampal convolution, the precuneus, and the postero-parietal gyres. (4) A *lobe of the special senses*, including the whole of the occipital and temporal lobes. (5) The island of Reil or insular lobe.

Differing views have been advanced as to the function of the island of Reil. With its adjoining parieto-temporal convolutions, it forms a distinct lobe, and is, as is well known, sometimes called the central

lobe or, the lobe of the insula. Its importance and size are possibly often not fully considered by the physician and surgeon, owing to the fact that in the average human brain it is so thoroughly concealed by the overhanging fronto-parietal convolutions and the temporal convolutions overlapping from below. The position, relations, and considerable size of the insula can be best seen in some of the brains in which development is arrested or aberrant, as in those of the negro, some criminals, and in the idiotic. Thus studying the lobe, it can be seen to be a great intermediate or binding lobe, probably connecting the other lobes of the brain so that their associated and related functions may be properly performed, and also for the same purpose uniting the ganglia with the different lobes.

Case of Trephining for Cortical Epilepsy.

Before entering upon the discussion of the subdivisions of the cortical motor zone, I will give the details of a case in which the principles of localization were called in to determine the position of operation. One object of introducing the history of the case here is because in fixing the position for excision of the cortex the faradic current was used, and certain results were obtained which assist in indicating the exact site of certain sub-centres of the motor zone, as, for instance, those for turning the head, for extension and flexion of the fingers and hand, and for drawing upwards and outwards of the angle of the mouth.

M., 14 years old, when two years of age had a series of convulsions coming and going during twelve hours, and followed by a stupor which lasted several days. Six years later he again had a series of severe spasms, the epileptic status continuing for several hours; he had a third similar attack about one year later. Since, during the past five years, he has had fifteen to twenty spasmodic seizures, the intervals between them having grown shorter, so that recently they had only been a few weeks apart. Before the convulsions he was usually nervous and excitable, and on coming out of them nearly always complained of pain above and somewhat in front of the left ear. He had always been of an excitable temperament; and unusual excitability was noticeable during the six years between his first and second attack of spasm. He was, however, a bright boy, of good disposition, affectionate and careful of himself, and his general health, as a rule, was excellent. He was seen in consultation with Dr. Wilson Buckby. Twelve days before he went into a severe convulsion, and from that time he had not spoken, and had had violent spasms with intervals, in the course of twenty-four hours having ten or more distinct paroxysms. In the intervals between the attacks, he was sometimes stuporous and some-

times in a condition of excitement, but his mind was continually clouded so that he did not appreciate his surroundings.

In every seizure of the series of spasms the convulsive movement began the same way; the fingers of the right hand first flexed, then flexion took place at the wrist and elbow, and the parts remaining flexed, soon the whole arm, forearm and hand were drawn upward and somewhat outward. As one of his family expressed it, "his right arm was drawn until it looked like a chicken's wing." His face and head, after the movements in the upper extremity were well under way, were drawn a little to the right, his leg at about the same time, as nearly as could be determined, taking part in the spasm, semi-flexing at the knee, and the toes and foot contracting. The signal symptom was always the same, namely, a movement of flexion of the fingers; and the spasm was always first and most marked in the right upper extremity; it was commonly unilateral, but sometimes became general. Between the paroxysms his right arm was often the seat of a tremulous vibratory movement. Examination in the interval between two seizures, showed slight paresis of the lower portion of the right side of the face, and more marked paresis of the upper extremity, particularly of the forearm and hand. This was always more decided after each convulsive attack. Although right-handed, he constantly used the left hand in preference to the right. Tactile sense could not be closely studied, but he undoubtedly appreciated sensations of touch, pain, temperature. Knee-jerk was somewhat exaggerated on the right side.

After several consultations it was decided to trephine, and if no gross lesion was discovered, to excise the cortex of the area or centre for the fingers and hand in the left hemisphere, because of the invariability with which the spasmodic symptoms began in the fingers and hand of the right side.

The trephining was performed July 28, 1888, by Dr. W. J. Hearn. At the operation were present, besides the writer and operator, Drs. W. Buckby, R. B. Burns, J. H. Lloyd, A. H. P. Leuf, W. M. Coplin, M. Imogene Bassette, J. C. Cooper and C. P. Noble. The head was shaved and prepared anti-septically. A sublimate solution was used and great care was taken with the instruments, sponges, etc. The line of the fissure of Rolando was determined by the methods of Hare and Thane, and a point was selected for the centre of the first trephine at what was considered to be the junction of the arm and face area, about three-quarters of an inch in front of the fissure of Rolando. A large horseshoe flap was made, its convexity backwards. Two trephine openings were made and bone cut away until finally the opening measured in its greatest diameter, which was from above downward, 2½

inches, and 1½ inches in its greatest width. The long axis of the opening was nearly in a line with the general direction of the fissure of Rolando. The region intended to be exposed was the lower two-thirds of the arm area, the upper anterior portion of the face area, the hinder upper part of the speech area, and a posterior strip of the area for movement of the head and eyes ; the convolutions uncovered were, therefore, presumably nearly the lower halves of the two centrals, the posterior extremity of the second frontal, and the posterior superior corner of the third frontal. No lesion of the bone or of the dura mater was found. On raising the flap of the dura mater, the pia arachnoid in the lower half of the opening was decidedly oedematous. No gross lesion could be found on inspection and close examination in the pia mater, cortex, or sub-cortex.

Careful examinations were made with the faradic current applied to the cortex with the view of locating the proper centres for excision. Four distinct responses in the shape of definite movements were obtained after several trials ; these were (1) in the most anterior position at which movements resulted distinct conjugate deviation of the head to the opposite side ; (2) a little below and behind this point, drawing of the mouth outwards and upwards ; (3) above this spot for movements of the angle of the mouth, about half an inch, extension of the wrist and fingers was produced ; (4) behind and above the latter point, distinct flexion of the fingers and wrist. Continuing and increasing the faradic application at this last determined point, the fingers, thumb, wrist and forearm were successively flexed, and the whole extremity assumed the " wing-like " position. The order of events, according to three persons who were present, and who had observed the patient's spasms, being exactly that which had been noticed in the beginning of his convulsive seizures.

As no gross lesion was discovered on careful examination and exploration, excision was performed of the cortex and sub-cortex so as to include the area excitation of which by faradism started the spasmodic movements of the fingers and wrist. The operation was concluded after the usual manner. The patient recovered from the operation without serious symptoms. In three days his mental condition was much improved ; the restlessness, irritability, and semi-maniacal condition which had been present before the operation passed away. His aphasia persisted. He had distinct paresis of the fingers and wrist, including the thumb, slight clawing of the fingers and bending of the wrist being present. This gradually improved.*

* January 3, 1889, it is reported to me that this patient has had no spasms since the operation. He has regained almost entirely the use of his right hand and arm. He is still aphasic, although he has acquired the use of a few words.

Subdivisions of the Motor Area.

In the area for face, head, arm, leg and trunk, the neurologist should be able to locate for the surgeon, through a study of motor phenomena, at least seven or eight different sub-areas; and in order to do this it is imperative for him to have exact knowledge, not only of the anterior and posterior limits, but also of the horizontal subdivisions of this zone. Too much stress cannot be laid upon the proper separation of the region into horizontal levels; for, as Horsley* has well put the matter, the variation in the representation of motor function is greater in passing over the motor area from above downwards than from before backwards.

Horsley suggests the horizontal subdivision of the motor area mentally by means of certain sulci and their imaginary extensions. The imaginary extensions backwards of the superior and inferior frontal sulci through the central or Rolandic fissure subdivide with approximate accuracy the pre-central or ascending frontal gyre into three areas or zones from above downwards, namely, for the lower extremity, upper extremity, and face. According to Horsley, also, a line drawn forward from the anterior lower end of the intra-parietal sulcus will mark distinctly the division between the representation of movements of the upper limb and of the face behind the fissure of Rolando. This suggestion, however, is not as good a one practically as that with reference to the two frontal sulci. In the human brain, at least, the lower end of the intra-parietal sulcus is by no means fixed; it is often as low down as the end of the central fissure. It is better simply to place the posterior part of the area for the face in the lower third or fourth of the posterior central convolution.

The old method of subdividing the motor zone was by cutting the fissure of Rolando into thirds, and locating a circular or elliptical area over each of these thirds on both sides of the fissure—and upper area for the lower extremity, a middle one for the upper, and a lower one for the face. Such a sub-division is not now exact enough for accurate topographical diagnosis for operative purposes.

Instead of subdividing the central or Rolandic fissure into thirds, it is better perhaps to divide it into fourths, placing the area of representation for the lower extremity in the first fourth; that of the face in the lower fourth, and the areas for the upper extremity include the second and third fourths. This makes the diagrammatic method of representation correspond more closely to the results of recent investigations, as the vertical extent of the arm region on the

* Am. Jour. Med. Sci., April, 1887, p. 342–369.

lateral aspect of the hemisphere is about twice as great as that for the leg and somewhat greater than that for the face. The fissure of Rolando does not extend usually as far as the Sylvian fissure, and therefore making the junction of the third and last fourths of the former fissure the upper boundary of the face area, gives this area a greater height than that for the leg, but not as great as that for the arm.

Although time will not permit lengthy consideration, it will be interesting briefly to discuss some of the ascertained facts with reference to the sub-areas or centres in this wonderful motor region.

Subdivisions of the Face Area.

In the first place, the face area is best subdivided into an upper and a lower sub-area. In the upper sub-area movement of the opposite angle of the mouth and of the lower face generally, are represented. In three cases during operations on human beings, I have observed faradization of the anterior superior portion of this face area produce contraction of the opposite angle of the mouth and face. It is probable that in the extreme upper anterior portion of this area, immediately adjoining the area for the head and eyes, is a sub-centre for such movements of the upper face as contraction of the frontalis and orbicularis palpebrarum muscles. Such a centre does not come out clearly as the result either of physiological investigation, or the experiments of disease, because associated movements are apt to remain even after destruction of a centre for such movements on one side of the brain. Of the face area Horsley and Schäfer say that it is physiologically remarkable, that many of the movements which result from its excitation are apt to be executed bilaterally, which is only exceptionally the case with excitation of the other areas (except that of the head and eyes). Excitation of the upper third or half of the area, they continue, causes winking or closure of the eyelids, elevation of the ala of the nose, and retraction and elevation of the angle of the mouth.

An observation of Dr. Berkeley, of Baltimore, helps to fix with positiveness the exact location of the cortical centre for the movements of the angle of the mouth, chiefly performed by the zygomatic muscles, in this upper anterior portion of the general area for the face at a point about opposite the usual position of the fissure between the middle and inferior frontal convolutions. Gowers, in his Manual of Diseases of the Nervous System, page 663, has a cut from a photo-

graph furnished by Dr. Berkeley, showing a small focus of softening in the ascending frontal convolution at this point. This very circumscribed focal lesion caused persistent clonic spasm, chiefly of the zygomatics. My observation on the case trephined by Dr. Hearn, confirms this position for the centre for this movement, as gentle faradization of the cortex at this spot caused distinct drawing of the mouth upwards and outwards. The centre for the orbicularis palpebrarum, as stated is doubtless in close proximity, probably just above the position of the centre for the angle of the mouth. While it is not usually the case, paralysis in the upper distribution of the facial nerve sometimes does take place as the result of cortical lesion. In one of my cases of tumor in the posterior portion of the second frontal convolution, and causing some destruction by the invasion of the ascending frontal, distinct lagophthalmus of the opposite side was present. No lesion of the cranial nerves at the base was present. In this case ptosis was present on the other side, that is, on the side of the lesion. The fact that in facial spasm whether secondary after a peripheral facial paralysis, or primary from nerve or central lesion—the orbicularis palpebrarum and zygomatic muscles usually act together so that the eye is closed or partly closed at the same time that the angle of the mouth is drawn upward, and the naso-labial furrough deepened, is clinical evidence in favor of the close proximity of the zygomatic and orbicularis palpebrarum centres in the cortex. Close examination of cases of hemiplegia and monoplegia will often show weakness of the movement of closure of the eyelids, in the paralyzed side, a paresis which would not be observed by a careless observer.

The lower two-thirds of the face-area may be divided into at least two parts, an anterior and a posterior. As the question of the exact function of this lower anterior portion of the face-area is one of considerable importance, and one about which some doubts still exist, I will briefly detail some of the facts with reference to this sub-centre. Beginning with the most recent contribution to the question, it may be first stated that Dr. Felix Semon, working in conjunction with Professor Horsley,* found that the lower end of the ascending frontal gyrus anteriorly is also excitable ; an effect being produced upon the glottis by its excitation, viz : to bring about phonatory closure of the vocal cords.

A fair amount of other evidence has been collected to show the existence of a cortical centre for laryngeal movements. In 1877,

* Phil. Trans. Royal Soc., vol. clxxix., 1888.

Seguin* reported a case of left hemiparesis without loss of consciousness but with impairment of speech, and also of phonation, the patient after the attack never being able to control the pitch of the voice, apparently from a lack of proper action of the muscles of the pharynx and larynx. Autopsy showed the surface of the right third frontal convolution degenerated, being yellow, tough, and elastic. The same change to a less extent was found in the same location on the left side. From such observations a motor centre for laryngeal movements has been sought for in the posterior extremity of the *right* third frontal (homologous with the speech centre on the left side, in right-handed persons).

Krause,† in the laboratory of Professor Munk, in 1883, investigated this question experimentally. On excitation of the cortex he noticed rise of the larynx, and movement of the vocal bands to a position midway between expiration and phonation, lifting of the palate, contraction of the constrictor pharyngis, and movements at the base of the tongue. With extirpation experiments he found that eight dogs had lost the power of barking, on attempting which they uttered only a hoarse whine or made a sound.

Delavan,‡ in 1865, contributed a paper on laryngeal cortical centres, in which he records some valuable facts and refers to the observation of Seguin, Krause and others.

Garel§ read before the French Society of Otology and Laryngology, in April, 1886, an interesting communication on the laryngeal cortical centre, and vocal paralysis of cerebral origin, in which he reported a case with the details of an autopsy and a sketch of the locality of the lesion. The inferior portion of the precentral gyre on the *right* side was slightly adherent to the meninges. The membranes being stripped the surface beneath presented a light yellow discoloration. At the foot of the third frontal gyre were two points of red softening, but there was no lesion of the anterior portion of the third frontal. On section, these lesions were found to involve only the cortical substance, at the upper part only very slightly invading the white. The lesion of the precentral penetrated slightly into the white substance. It would seem from these experiments and observations that a centre for the movements of the larynx and throat is in the extreme lower anterior portion of the pre-central convolution, and that it is probably better differentiated in the right than in the left hemisphere.

* Referred to by Delavan in Med. Rec., N. Y., Feb. 14, 1885.

† Cited by Horsley and Schäfer and Delavan.

‡ Med. Rec., N. Y., Feb. 14, 1885.

§ Annales des Maladies de l'Oreille et du Larynx. Tome xii., 1886, p. 218.

Somewhat numerous pathological observations corroborate the existence of Ferrier's oro-lingual centres also in the lower anterior portion of the face area, probably a little behind the centres for the throat and larynx. In these oro-lingual centres are located particularly the representation of the movements produced by the orbicularis oris, and of protrusion of the tongue. Recently a case of typical oro-lingual paresis with involvement of this region has been observed by me, some details of which will be given later when speaking of the alleged sensory functions of the motor cortex. Pathological observations also somewhat numerous have confirmed the position of Ferrier's centre for movements performed by the platysma myoides muscle in the face area behind the Rolandic fissure.

In the hinder lower portion of the face area is probably represented opening and shutting movements of the mouth, and retraction of the tongue.

Intra-cerebral Facial Tracts.

The existence and location of separate intra-cerebral facial tracts is a subject bearing a direct relation to that of the cortical areas and sub-areas for the face, and also a matter about which our knowledge is scanty.

Kirchoff,* in 1881, reported the case of a man aged 24, who had several attacks in which he became giddy, had convulsive tremors, lost power of speech, was unable to swallow, had profuse salivation, and drawing of his face to the left. Examination showed that he articulated with difficulty; labials and gutturals especially were troublesome; linguals he spoke with comparative ease. The lips were moved little in speaking; he could not whistle, but was able to approximate the lips. Saliva flowed from the mouth and there was excessive secretion of tears. The tongue was not protrusible more than one centimetre from the mouth, and it moved clumsily in the act of biting. At the time of examination swallowing was unimpeded, but the glottis was closed tardily. The patient often laughed without occasion. There was disease of the mitral valve. Ten days before death his face was suddenly drawn to the right, and his left arm and leg became powerless. Convulsions occurred from time to time up to his death.

The post-mortem revealed embolic softening of the posterior two-thirds of the right corpus striatum (caudate nucleus), the underlying

* Archiv. f. Psych. Bd. XI,, and Brain, July, 1881.

internal capsule, the outer segment of the lenticular nucleus, the claustrum, external capsule and island of Reil. The focus of softening in the lenticular nucleus was distinguished from the other softened portions by being surrounded by a wall of compact sclerosed tissue. Careful microscopic examination failed to show any disease of the medulla or pons. The author atributes the glosso-labial paralysis to the lesion of the lenticular nucleus ; and the hemiplegia to the quite recent lesion of the caudate nucleus, internal capsule and other parts. Cases of bilateral affection of the face, tongue, and throat, caused by unilateral lesion of the cerebrum, are rare ; the author cites two, recorded by Lepine and Magnus respectively.

Ross,* also reported a case of brain disease simulating bulbar paralysis in which the lesions were cerebral, in the ganglia and alongside of them in the capsules. In 1880, I observed a third similar case at the Philadelphia Hospital.

Hobson,† in 1882, reported a case without autopsy—the main symptoms being left hemiparesis or paralysis, or paralysis of the tongue, difficulty of deglutition, speechlessness, clenching of the jaws ; the patient had one inarticulate sound for everything, and a slight sound on laughing. In 1882, Ross,‡ in an interesting paper on labio-glosso-pharyngeal paralysis of cerebral origin, traversed the literature of the subject, giving also some interesting original observations.

Subdivisons of the Arm Area.

The subdivision of the area for the upper limb, according to Horsley, is for the shoulder in the upper part, the elbow next below and behind, the wrist next below and in front, the thumb lowest and behind. In the area just above the superior frontal sulcus the movements of the lower and upper limb are absolutely blended, most markedly in the hinder sixth of the superior frontal gyre. Sometimes an epileptic fit from a lesion centred here begins by complicated or generalized movements of both extremities on one side.

At various points on the posterior central convolution, Ferrier, it will be remembered, fixed centres, excitation of which caused flexion of the thumb and fingers and firm clenching of the fist, with the synergic action of the wrist and fingers, but he did not differentiate centres for different flexors and extensors. From my own observation, I believe that the centres for movements of extension of the fingers and wrist are a little anterior and below those for flexion of the same parts.

* Diseases of the Nervous System, vol. ii.

† Brit. M. J., April 29, 1882.

‡ Brain, July, 1882.

In one of Keen's operations* the position of the hand centre was fixed by means of the faradic current. The fissure of Rolando was determined by both the methods of Hare and Thane. The trials with the faradic currents were made according to the determination of Dr. Keen, on both the post-Rolandic (post-central or ascending parietal), and pre-Rolandic (pre-central or ascending frontal) convolutions, and also the posterior extremity of the second frontal convolution. Excitation of the post-Rolandic convolution produced no effect. On touching the cortex with the electrodes at a position which apparently corresponded to the anterior portion of the pre-Rolandic convolution just back of the precentral fissure, movements of the wrist and fingers were produced. The hand moved in extension in the mid-line and to the ulnar side at different touches, the fingers being extended and separated. Above the region in which these movements were obtained, application of the current caused movement of the left elbow, both flexion and extension, and of the shoulder, which was raised and abducted. Below the region where the hand movements were excited the application of the current produced an upward movement of the whole of the left face. In the cases of Hearn and the writer, reported above, the exact movements described by Keen were produced, that is, the extension at the wrist and separation of the fingers ; also, below the spot where these movements were produced, an upward and outward movement of the face, or rather angle of the mouth. In our case, however, elbow and shoulder movements were not produced except as a secondary result. We obtained, however, a primary movement of flexion of the fingers and hand to which Keen does not refer, and which presumably was not produced. This movement resulted from touching with the electrodes a spot a little above and behind the place where the movements of the extensors were caused. Continuing and increasing the strength of the faradic applications at this point, flexions took place in succession of the fingers and thumb, and at the wrist and elbow. Keen estimated the portion of the convolution as containing the hand centre as about $1\frac{1}{4}$ inches long, and he places the centre for the wrist and fingers in the pre-Rolandic gyrus, its lower limit being at three-eighths of an inch above the temporal ridge, and its upper end where it fused with that of the elbow 32 millimetres higher up. The shoulder he placed still higher, while the centre for the upper face was in the same convolution below. These results correspond closely with those of Horsley. These facts of experiments on man would seem to uphold the view that the motor zone, in man at least, is much more extensive in front of than behind the

* Trans. of Am. Surg. Association, vol. vi., 1888, and also in the Am. Jour. Med. Sci., November, 1888.

fissure of Rolando. These results of Keen were all produced by excitation of the cortex anterior to the fissure of Rolando, supposing, of course, his determination of that fissure to have been correct. As nearly as I could determine the location of my own results were the same.*

I was present at the operation in the case of Lloyd and Deaver.† By following Reid's and Horsley's lines, an area was exposed which was supposed to be on both sides of the Rolandic fissure, about the junction of the middle and lower thirds of the central convolutions. The faradic current was then used to identify locations. When the electrodes were applied to a point which was supposed to be just back of the fissure of Rolando, the movements which occurred were in order turning of the thumb on the palm, flexion of the fingers, flexion of the wrist extending to flexion of the elbow. At a point in front and below faradic stimulation caused marked contraction of the face muscles of the opposite side. "The mouth began to contract and was drawn to the left with a tremulous motion, and soon the tongue began to protrude toward the left corner of the mouth. Soon the left thumb began to be contracted and adducted into the palm; then the fingers contracted into the palm, and about the same time the face muscles began to contract more actively, while the head was drawn to the left, and the left eyelid began to work. At the same time the hand was gradually closed, and contraction of the forearm and arm began, while the latter was drawn from the side to an angle of forty-five degrees (deltoid action), and contractions of the biceps occurred. At no time in the course of these faradic applications, anywhere within the area exposed by the trephine and forceps, did any contraction of the leg muscles occur."

Subdivisions of the Leg Area and of the Trunk Area.

The movements of the lower extremity are represented in the upper portion of the motor area, and the adjoining marginal convolution; probably hip and thigh movements on the lateral and mesial aspects of of the hemisphere near the median fissure, well formed in the area, and

* October 4th, 1888, since the meeting of the Congress, Nancrede of Philadelphia, before excision of the cortex fixed the position of the thumb centres by means of the faradic current. The patient suffered from convulsions which began with strong flexion of the right thumb, followed by extension of the wrist and fingers, pronation of the forearm and hand, flexion at the elbow, powerful flexion and rotation of the head to the right, thrusting out of the tongue between rigid jaws, and coincident with all conjugate ocular deviation to the right. The spot at which the faradic current was applied was estimated by Nancrede, to be from below upwards in the second fourth of the ascending parietal convolution.—*Medical News, November* 24, 1888.

† Since reported in the Am. Jour. Med. Sci., November, 1888.

movements of the leg and toes farther back on the lateral aspect and also in the para-central lobule, and marginal convolutions of the median surface.

A narrow strip of the anterior portion of the leg area appears both from the results of experimentation, and of pathological and surgical observation to be a trunk-area, this being larger proportionally on the mesial than on the lateral aspect of the hemisphere, as represented in the diagrams. Horsley and Schäfer occasionally obtained movements of the trunk when the electrodes were applied to the lateral surface near the margin of the hemisphere. On the adjoining mesial surface, however, excitation produced rotation and arching of the lower spine and the pelvis, and extension of the hip, movement of the tail to the opposite side, and flexion at the knee.

Horsley* says that at the summit of the ascending frontal gyrus begins the representation of the lower limb only, the primary movement being that of the hallux. He describes a case of traumatic epilepsy the primary movement consisting of flexion of the hallux followed by the gradual flexion of the rest of the lower limb, and that followed by successive invasion of the rest of the lower body in the usual order. A dense and cystic cicatrix was found at the upper end of the ascending frontal gyrus. In another case, in which a tumor was removed, and with it the cortex in front of the upper end of the fissure of Rolando, the only permanent complete paralysis of the lower limb was that of the hallux. In one of my own cases a small gumma involved the upper fourth of the ascending frontral, and a smaller segment of the ascending parietal, crossing the upper extremity of the Rolandic fissure. This patient had severe attacks of left sided spasm beginning with twitchings in the left toe and foot ; she also had partial paralysis of the left leg and arm, most marked in the leg. The leg area, however, as shown by Horsley and Schäfer, is largely situated upon the mesial surface of the hemisphere. According to these authors, the excitation takes effect chiefly upon the ankles and digits, producing most commonly flexion of the foot with flexion of the digits. The most marked movement in front of the upper end of the Rolandic fissure is flexion of the leg at the knee, with the addition, when the electrodes are applied more anteriorly, of flexion at the hip.

Area for the Movements of the Head and Eyes.

I cannot agree with Seguin in the recent paper by Weir and Seguin† that the centre for ocular movements is quite certainly not in the second frontal gyre as claimed by Ferrier and Horsley. Much is in favor of the view that it is situated in this neighborhood.

* Am. Jour. Med. Sci., April, 1887. † Op. cit.

In one of the cases of Horsley, in which operation was performed at the point of the meeting of the areas for the movement of the trunk, protrusion of the upper limb, and turning the head and eyes, the aura was contraction of the abdominal muscles followed by turning of the head and eyes to the opposite side. Other cases have been reported in which turning of the head was the starting point of the spasm. In some cases, at least, when the aura or signal symptom can be most certainly shown to be the turning of the head and eyes to the side opposite to the supposed site of the lesion, the probabilities are that the focus or primary seat of the irritation is from a lesion in this oculo-motor region. The fact that cortical oculo-motor palsies are not present as a persistent condition even when we have definite lesions of the second frontal gyre is not an argument of weight against the existence here of oculo-motor centres. Such persistent oculo-motor paralysis was not present in one of the best defined cases of lesion in the second frontal gyre ever reported, a case occurring in my wards at the Philadelphia Hospital. Such symptoms do not persist because of the automatic nuclear mechanism of the cranial nerves related to these centres.

In the last edition of Ferrier's Functions of the Brain, he adheres to his views as to the position of the oculo-motor centres, and gives some new experiments bearing upon the subject. Irritation of the base of the superior and middle frontal convolutions in monkeys, gives rise to lateral movements to the opposite sides with dilatation of pupils. The expression assumed by the animal is that of attention or surprise. The same movement, however, as Ferrier himself states, also occurs along with other special reactions, on stimulation of the angular gyrus and superior temporo-sphenoidal convolution more especially. With the latter is associated pricking of the ear from stimulation of the auditory centre. Ferrier argues that although the effects are the same the causes are different. Stimulation of visual and auditory centres attract attention movements, the same as would result from stimulation of the motor centres for those movements. Destruction of the oculo-motor centres of Ferrier, according to some experiments, causes conjugate deviation towards the side of the lesion. Bilateral destruction of these centres for the first day caused inability to turn the head and eyes, but the animal recovered. Horsley and Schäfer, and Ferrier also, got no motor or sensory symptoms from lesion of the pre-frontal lobes, except in one case in which the paralysis of the lateral movements of the eyes following the lesion of the post-frontal centres having completely disappeared, the destruction also of the pre-frontal regions caused rapid oscillations of the head, apparent in-

ability to turn the head except en masse with the trunk, and drooping of the right eyelid. These facts, according to Ferrier, show that the pre-frontal regions belong to the same centres as the post-frontal, just as the occipital lobes belongs to the visual centres.

Attempts have been made to remove the post-frontal as well as pre-frontal region. The animal could not maintain the upright position or move its head and eyes laterally. The eyes were kept shut except on cutaneous or other sensory stimulation. Some microscopical examinations of degenerations of tracts seem also to prove that the post-frontal regions contain the oculo-motor centres. Descending sclerosis from the innermost or mesial bundles of the internal capsule, does not extend below the pons, but probably into the oculo-motor nuclei.

Horsley believes that the focus of representation of the movement of the turning of the head and eyes to the opposite side is in the middle frontal gyre, but also that these movements have a much more extensive representation.

"It must be left, for the present," he says, "an open question as to how far the representation of this important and interesting conjugate movement extends *forward* in the frontal lobe. A definite answer can only be given when the homologies between the sulci and the frontal lobe in the Macaque monkey and man have been thoroughly determined. That this area of function is continued over the margin of the hemisphere into the marginal convolution, has already been shown by Professor Schäfer and myself. * * * *

"In every instance the head and neck are turned to the opposite side, and in some parts there is produced at the same time or later, conjugate deviation of the eyes."

Horsley and Schäfer in their contribution to the Philosophical Transactions, speak as follows with reference to this area: "The *head-area or area for visual direction* comprises an oblong portion of the surface of the frontal lobe, extending from the margin of the hemisphere, round which it dips for a short distance, outward and somewhat backward to the upper and anterior limit of the face-area. Posteriorly, it is bounded by the arm-area, and in front by the non-excitable portion of the lobe. It extends, therefore, in front as far as the extremity of the precentral sulcus, and it includes the middle part of the frontal lobe above the antero-posterior limb of the sulcus, the part included in the angle formed by the antero-posterior and vertical limbs of the sulcus, and perhaps a small portion of the ascending frontal gyrus, close to the vertical limb of the same fissure. The effects produced by excitation of this are similar to those described by

Ferrier as resulting from excitation of the rather more limited area marked 12 in his diagrams, viz: opening of the eyes, dilatation of the pupils, and turning of the head to the opposite side, with conjugate deviation of the eyes to that side. If the electrodes are applied near the angle of the precentral sulcus, the ears are frequently also retracted."

In the patient referred to in whose case trephining was performed a weak current applied forward of the position at which movements of the fingers and hand were produced, caused distinct deviation of the head to the opposite side. As nearly as could be determined the electrodes were applied over the extreme posterior portion of the second frontal gyre.

Conjugate deviation of the head and eyes, when a persistent or permanent symptom, is most likely to arise from lesions of the pons, cerebellum or cerebellar peduncles.

I have thus tried to indicate the recognized centres and sub-centres of the motor zone. To such great works as that of Ferrier on the *Functions of the Brain*, and to such monographs as those of Horsley and Schäfer, Horsley and Beevor, and Seguin, I must refer those especially interested in obtaining fuller details.

Overlapping Areas.

Some of these areas it will be seen apparently overlap each other, so far as their cortical representation is concerned, hence giving positions for trephining in some cases over the border of two adjoining areas. It might be said that with a large trephine it will not be necessary to separate and localize so many areas, as an opening 1½ inch or 2 inches can be made, and even this can be enlarged by the rongeur until a suspected lesion is reached, but this is a crude method in these days of precision. Even in cases of comparatively large lesion, the complete success of the operation will depend somewhat upon the first position in which the opening is made. The ideal position would of course be one that corresponded to the centre of the lesion.

Wonderful indeed is this motor zone of the cerebrum, a marvellous mosiac of centres of function, wrought from the great conceptions and priceless labors of the artists of our own guild ; a mosiac, to each block, angle and jointure of which the neurologist can point the surgeon and say, cut here or there, or touch not this or that.

Different Classes of Localizing Symptoms, their Characteristics and Comparative Value.

The neurological diagnostician must make use of his knowledge of these areas after a definite plan, if he wishes to turn it to the best account.

When localizing lesions he must go beyond even the important distinction advanced by Brown-Sequard, and very properly insisted upon and elaborated by all subsequent writers upon localization, namely, the differentiation between symptoms of irritation and those of destruction. He should appreciate the possibility of six classes of symptoms presenting themselves for his consideration, namely, those of (1) local irritation, (2) local destruction, (3) local pressure, (4) invasions by lesions growing from adjacent areas to those under determination; (5) local instability, (6) reflex action at a distance.

In this connection I will only treat broadly of a few points, as the necessity for this subdivision of symptomatology becomes apparent when considering localization in special regions. In the motor zone the symptom of irritation is especially spasm; but irritation symptoms may occur in other localities. In the visual, aural, olfactory, gustatory, or cutaneous areas they may take the form of hallucinations or other perversions of the senses. Symptoms indicating destruction are, in the motor areas, paresis or paralysis, and in other regions such manifestations as hemianopsia, word or mind blindness, word deafness, anæsthesia, analgesia, anosmia, etc. Pressure and invasion symptoms may, of course, be indicative of irritation or destruction, but are considered by the clinician in their relations to special areas under process of determination. Invasion symptoms will at first commonly be phenomena of irritation, and later both of irritation and destruction. By symptoms of instability I refer to those manifestations which occur as the result of discharging cortical areas without demonstrable gross lesions. Symptoms of reflex action will occur mostly in connection with lesions of the cranial or other nerves, and of the cerebral membranes, particularly the dura mater. They will receive particular attention when discussing some of the sources of error in motor localization.

Certain characteristics, both general and special, of cortical spasm should be well understood. These have been best studied by a few observers, such as François-Franck and Horsley. In Franck's great work the peculiarities both of cortical, sub-cortical and capsular spasm have been determined by electrical experimentation, and are carefully described and graphically represented, the phenomena having been en-

registered. Horsley, practically concurring with Franck, enumerates these characteristics as the presence of a period of latency, then tonic spasm, then clonic spasm, arrest of respiration with cyanosis and salivation.

A study of the initial symptom or sign in a case of irritative cerebral lesion, and also of the serial order of phenomena, may be of the utmost importance. Seguin has proposed to call this initial symptom the "signal symptom." Horsley's view of the manner in which movements are represented in the motor cortex is that in any given part of the cortex as minute as can be examined experimentally, there is represented a definite movement or combination of movements, being the primary movement and elicited by minimal stimulation only ; and that secondary movements are due to the subsequent invasion by the discharge of nerve energy of portions of the cortex which lie nearest to and are in close relation with the parts stimulated. The primary movement gives the signal symptom of Seguin, and the secondary movements represent the "serial order" of phenomena.

The signal symptom in Jacksonian spasm has already been made use of in a number of cases to guide the surgeon in part or whole in selecting the site for operation.

In one of Horsley's cases there was first tonic extension and clonic spasm of the right lower limb. "The right upper limb was then slowly extended at right angles to the body, the wrist and fingers being flexed ; the fingers next became extended, and the clonic spasms of flexion and extension affected the whole limb, the elbow being gradually flexed. At this time, spasms in the lower limbs having ceased, those in the upper limb continued vigorously. The spasm gradually affected the right angle of the mouth, spreading over the right side of the face, and followed by turning of the head and eyes to the right."

In another case first came "clonic spasmodic opposition of the left thumb and forefinger. The wrist next, and then the elbow and shoulder were flexed clonically, then the face twitched and the patient lost consciousness. The hands and eyes then turned to the left, and the left lower limb was drawn up. The right lower limb was now attacked, and finally the right upper limbs. Paralysis of the left upper limb frequently followed a fit. At frequent intervals every day the patient's thumb would commence twitching, but the progress of the convulsion could often be arrested by stretching the thumb and applying a ligature."

In another case by the same surgeon the spasm was ushered in with a desire to defecate, sometimes with sharp pain in the left side of the

belly. Then followed tightness of the throat, and sometimes spasmodic cough. Then the head and often the eyes turned to the right; the right arm was jerkily protruded, and the patient became unconscious. All the limbs became powerfully flexed, as a rule, but the lower limbs were frequently extended.

Weir and Seguin, Keen, Lloyd and Deaver, the writer, and others have taken advantage of the signal or initial symptom in fixing a site for operations, and thus, either with or without gross lesion, hand centres, thumb centres, face centres, etc., have been excised.

Even movements of the trunk have been used to guide operation by Horsley.* "As regards the trunk muscles," he says, "much might be said, but reference for detail is invited to the above mentioned paper in the Proc. Roy. Soc., 1885. It is, however, worth while pointing out, psychologically speaking, that there is scarcely ever performed a highly purposive act by the trunk muscles only. The movements of the trunk are simply subordinate to the purposive movements of the limbs, and consequently we should not be surprised to find, as in this case, how extremely small a portion of the cortex is sufficient for primary representation of this part of the body. An illustrative case of the position in the human brain of the areas we have just been considering, is that of a case in which a man had been a victim of traumatic epilepsy for many years due to a small punctured fracture of the skull, the said fracture being demonstrated externally by a minute depression three or four millimetres broad. The puncture had caused splitting of the inner table, laceration of the dura mater, and partial destruction of the subjacent cortex, so that at the time of operation (eleven years later) there was found a rough ring of bone on the inner surface of the skull around the centre of the fracture, from which a sharp and corrugated fragment, one cm. long by five mm., broad projected downward, together with a flap of entangled and torn dura mater, into the wall of a small cystic cavity in the cortex just above the junction of the middle and posterior thirds of the superior frontal sulcus. This fairly extensive lesion, which was freely removed (the result being cure of the epilepsy), was thus situated at the point of meeting of the area for raising with protrusion of the upper limb, and of that for turning the head and eyes to the opposite side of the body. The existence of such a lesion was diagnosticated from the fact that the course of events in the epileptic fit began with an aura of contraction of the abdominal muscles, this was followed by turning of the head and eyes to the opposite side, and then there occurred the raising of the upper limb. The exemplifications of the topographical relations of these centres was thus faithfully demonstrated."

* Am. J. Med. Sc., vol. xciii., n. s. 1887, p. 367.

Sub-cortical Lesions and the Intra-cerebral Tracts.

It will be well to say a word or two here about the diagnosis of sub-cortical motor lesions—tumor, cyst, hemorrhage or abscess—which has practical importance, not only for its own sake but chiefly because, in some instances, the question of proceeding with an operation might depend largely upon the supposition of a lesion being sub-cortical. In the case of Weir and Seguin, after the flap of the dura mater was reflected and the brain exposed, nothing abnormal was seen on the exposed surface, and the finger at first recognized no tumor nor abnormality; but at the depth of nearly an inch a small growth was found. If the probability of the presence of a sub-cortical lesion had not been fully considered in this case the operation might have been absolutely fruitless. After a somewhat elaborate study of the question of the diagnosis of sub-cortical tumor, Seguin concludes that in favor of a strictly cortical or epi-cortical lesion are these symptoms, none of them having specific or independent value: "Localized clonic spasm, epileptic attacks beginning by local spasm, followed by paralysis; early appearance of local cranial pain and tenderness; increased local cranial temperature. In favor of sub-cortical location of tumor: local or hemiparesis, followed by spasm; predominance of tonic spasm; absence, small degree, or very late appearance of local headache, and of tenderness to percussion; normal cranial temperature."

The neurologist will probably in time be able in some cases to diagnosticate with sufficient accuracy for surgical purposes, lesions so situated as to destroy intracerebral traits in various regions of the brain. Studies of the different forms of aphasia demonstrate the truth of this proposition. As the various sensory and receptive centres concerned in the production of speech are situated in the parieto-temporal and temporal regions of the brain, the tracts connecting these areas with the motor or emissive speech regions, both for proposition and utterance, must lie in a space of a few inches from before backwards and from above downwards in the region bordering or lying within the Sylvian fissure.

Starr* has brought together in compact form some of the most important facts bearing upon the physiology of the intra-cerebral tracts, drawing largely upon Nothnagel, Charcot, Strumpfell, Flechsig, Edinger, Exner and Spitzka. At least three sets of fibres are to be distinguished in the centrum ovale, namely, the projection, commisural, and association systems. The projection system joins the cor-

* Med. Record, Feb. 13, 1886.

tex with parts of the nervous system below; the commisural system corresponding areas of the two hemispheres; the association system different convolutions of the same hemisphere. The investigation of these different systems is an intricate study, still involved in much obscurity; but it does not come within my province to consider it in this paper except in the most practical way, in connection with the localization of gross lesions.

A careful, elaborate, clinical study of hemiplegias, monoplegias and aphasias, will eventually enable us to separate with considerable certainty lesions of the cortex from those of the centrum ovale, capsules, and ganglia. We will do this by relating the symptoms found not only to lesions of the cortex and the projection system of fibres, as is too commonly the restriction placed on our studies in this direction, but also, to lesions of commisural and association fibres. I am convinced that a lack of consideration of these commisural and association fibres is at the bottom of much of our confusion in analyzing certain cases. Very few lesions are absolutely cortical. Many of those which are generally regarded as cortical, involve to a greater or less extent the sub-cortex. As every convolution of the cerebral surface is connected with some other, and probably with many other convolutions, some association fibres must nearly always be destroyed in these cases.

Differential Diagnosis, particularly of Jacksonian Epilepsy—Dural and other Reflex Epilepsies.

Sufficient diagnostic difficulties are still present to make it important in the light of the tremendous impetus towards operations to carefully examine all questions of differential diagnosis. We should know, in connection with cerebral motor localization, whether certain affections do not simulate cortical epilepsy so closely as to sometimes endanger exact diagnosis. In certain motor and especially spasmodic affections, for example, we have striking resemblance between affections clearly of reflex origin and those as demonstrably central. Trigeminal epilepsies, whether dural, facial, dental, nasal, pharyngeal, laryngeal, or of whatever local origin, may cause unilateral convulsions or even monospasm. Brown-Sequard has contributed largely to our knowledge of this subject both in his early and recent researches. During a few years stimulated by practical specialism, much work in the direction of diagnosis and treatment of reflex epilepsy has been done, some of the best of it by members of the Associations represented in this Congress. The same conclusion might be arrived at for all, as that of

Boucheron * with reference to aural epilepsy, namely, that spasm may proceed from lesions of the ear, eye, nose, pharynx, larynx, face, scalp, or dura mater, and may present all the clinical varieties of epilepsy, or even a form of hystero-epilepsy ; and that the point of origin of these disorders is intense excitation of a sensory nerve.

Dural epilepsies are especially worthy of attention. During a recent operation in one of the Philadelphia hospitals a faradic current accidentally applied to the dura mater, almost instantly produced spasm which invaded the whole body. Dupuy† has published various papers regarding irritation of the dura mater causing muscular movements, claiming that his results are constant when the animal experimented upon is not in a state of anæsthesia incompatible with the manifestations of animal life, and when it has not lost too much blood. Brown-Sequard and Burdon Sanderson have recorded similar phenomena; and the facts of these experiments have been used as arguments against cortical localizations. The Committee of the New York Society of Neurology and Electrology, in 1874, found that galvanization of the dura or other sensitive parts produced by reflex action, muscular twitchings, oftenest on the same side of the body. Duret‡ has given particular attention to the rôle played by the dura mater in the production of sensory, spasmodic, and other phenomena. He does not, however, with Dupuy, hold that the fact of the production of spasms in this way in the least invalidates the doctrine of cortical motor localization, but that a clear differentiation between dural and cortical spasm can be made. Bochefontaine has shown that irritation of the dura mater determined cries of pain, and general movements more or less energetic ; and also that mechanical irritation of the sensitive points of the membrane produced, in certain conditions, movements limited to one or several parts of the body, the movements of the limbs on the same side being more energetic than those on the opposite side. Franck has made careful comparison and contrast of cortical epilepsies and those which are reflex and toxic, including those which are due to irritative lesions of the dura mater. In one of his experiments§ he produced an epileptic seizure from mechanical irritation of the dura, and among other things noted was that at the moment of the irritation of the dura mater the muscles of the face of the same side were attacked with violent convulsions. Attacks followed, as many as nine in twenty-five minutes, all clonic and generalized.

* Compt. rend. Acad. de Sc. Paris, 1887, cv., 944–947.

† Examen de quelque points de la physiologie du cerveau. (Thèse inaugurale, Paris, 1873). Also: Experiences sur les functions motrices du cerveau, 1888. Compt. rend. des séances de l'Acad. des Sci.

‡ Sur les Traumatismes Cérébraux, and Brain. April, 1878. § Op. cit., p. 470.

The following is an abstract of the record of this experiment :

"Experiment No. 45 (Jan. 7, 1879) with M. Senna of Coimbæ. Reflex attack of epilepsy (excitation of the dura mater) commencing on the side irritated.—State of disease.—Arrest of the salivary flow in the attacks.—New series of reflex attacks by incision in the skin.—Circulatory modifications in this form of epilepsy.

"A young dog, spaniel of large size, very vigorous. The motor zone was exposed at the right side while under the influence of a slight anesthetic of chloroform ; a large opening was made in the frontal sinus in order to discover the excitable region, the crucial edge forward.

"It was proposed to study at the same time with salivation, the modifications of the heart and of compression, in their connection with the cortical origin of convulsions ; but the animal was taken with a reflex attack of epilepsy under the following conditions : The dura mater had been cut all round the trephining point ; a fragment remained adherent to the anterior inferior angle of the wound and caused a slight flow of blood somewhat interfering with the experiments at excitation. At the time when an attempt was made to stop the flow of blood with a piece of medicated cotton, the simple friction of the strip of dura mater provoked a series of violent convulsive attacks, having their point of commencement in the muscles of the face and neck on the *same side* (contrary to the epileptic attacks of cortical origin which *always* commence in the opposite side of the body, and severely in the corresponding muscles to the cortical centre excited.)

"The first attack was exclusively clonic, very violent and generalized.

"During several minutes spontaneous attacks succeeded, separated from one another by a few seconds only ; at the fourth attack the convulsive movements and the salivary escape were simultaneous. It was remarked in the first periods of the attack the salivation came on slowly ; it appeared in this fourth attack only thirty-two seconds after the commencement of the clonic movements.

"The animal had nine grand attacks in succession in twenty-five minutes. Then exhaustion came on and it was quiet, the respiration rapid, the heart beats quick, and the arterial pressure much diminished.

"It was left to repose for half an hour, then wishing to apply a manometer to the femoral artery, an incision was made in the skin of the thigh. At this moment a new convulsive explosion came on and without pauses, in the same register as had been made in the former attacks." * * * * *

The nerves of the dura mater spring from the fifth pair, and are distributed nearer to the internal than to the external surface of the membrane, which explains why some lesions of the dura are more likely than others to lead to spasm. The difference depends, in part, at least, on the site and intensity of the lesion with reference to the internal and external aspects of the membrane. Sub-dural hemorrhage is more likely to give rise to reflex spasms than extravasation between the membranes and the skull, unless the blood tears through the membrane. A spicule of bone, in like manner, driven

into the dura is more likely to cause reflex dural spasms than a depressed fragment ; while a tumor arising in the membrane is more likely to bring about the same result than an exostosis, or a neoplasm growing from the agglutinated membranes into the brain substance, as is so often seen in intra-cranial growths.

I have notes of five cases in which operations have been performed for epilepsies apparently reflex in character. In two of these spicules of bone were removed from the dura mater. These cases bear out to some extent the views of the existence of distinctive characteristics for reflex epilepsies, but also point to certain resemblances to cases of cortical epilepsy. In one case in which fracture was present in the left frontal region, anterior to the motor area, the patient had convulsions at irregular intervals of weeks or months ; usually having sharp pain at the seat of the scar before the seizure. He had no loss of sensation nor paralysis. His convulsions were frequently unilateral ; I saw him in one which was confined entirely to the left side, and began in the left leg. This case was trephined for me by Dr. W. J. Hearn, of Philadelphia, and a spicule of bone dissected from the dura mater. In another case the patient was trephined by Dr. J. W. White at my request, for a fracture from a pistol-shot wound just above the right temple. Nearly three months after the injury he began to have spasms ; and had had about seven seizures in all. In a convulsion which I witnessed he was completely unconscious ; his body was twisted somewhat to the right ; his face and all his limbs as well as his head and trunk taking part in the spasm which was tetanic in character. In another case in which an operation was performed for me by Dr. Hearn, the spasm seemed to show a somewhat confusing admixture of what might be termed dural and cortical characteristics. Notes on this case were furnished to Dr. J. B. Roberts, and were published by him in his pamphlet on the Operative Surgery of the Human Brain. In a fourth case seen with Dr. L. W. Steinbach, the patient had been subject to convulsions which seemed to date back to an injury to the head ; he had a scar and apparently a depression of the skull over the frontal region. Pressure on this scar brought on a unilateral, largely tetanic convulsion on the same side as the scar. A flap including the scar was lifted, and trephining was performed, but nothing abnormal was found in the inner table or in the dura. The scar was excised. In a fifth case, the patient had convulsions, sometimes on one side, sometimes on both, and these could be brought on by pressure on a scar left by an old sabre cut. The cicatrix was cut out and the patient recovered, at least, he remained for several months in the Hospital without attacks, although before the operation he had been having them at frequent intervals.

With Franck I fear we are not always able to make a trenchant separation between cortical and reflex epilepsies; but a few points may be indicated. In reflex epilepsy the attack does not begin with brusque tetanization as in the case of cortical disease. If the reflex epilepsy has a tonic period it rises slowly to its maximum. In cortical epilepsy the convulsion begins without exception on the side of the body opposite to the side of the brain excited or irritated; in reflex epilepsy, or at least in dural and perhaps other forms of trigeminal spasm, it frequently begins on the same side as the focus of irritation. Unfortunately we have not here a radical difference as it may begin on either side in reflex cases. In the reflex cases if the spasm begins locally or unilaterally, there is not likely to be a definite initial or signal symptom and serial order of movement; one half of the body usually plunges immediately into spasm.

True Jacksonian epilepsies are, I believe, sometimes reflex in origin; that is, they become established as the result of intense persistent peripheral irritation, dural, dental, palmar, etc.; and even after the source of irritation is removed the cortical discharges continue. Herein perhaps lies the explanation of Jacksonian spasm in which gross lesion is not discovered, and herein also sometimes is to be found justification for operation for the removal of cortical discharging areas, even when such lesion is not present. Such a method of origination of cortical epilepsy is in accordance with physiological principles. Meynert,* in the development of his idea of a projection system, has perhaps more clearly than anyone else made apparent the method in which this result may be brought about. Movements which were originally reflex in character may after a time result from cortical impulses. In the normal brain no reflex actions can be performed without exciting to action secondary volitional movements which no longer requires the stimulating influence of a reflex action. Some of the observations and experiments in hypnotism, as those of Heidenhain† in particular, also throw some light upon the manner in which reflex epilepsies may develop into true organic cortical disease. The phenomena of unilateral hypnosis are particularly interesting in this connection. When certain definite cutaneous surfaces are irritated, certain muscles and groups of muscles related to these areas can be brought into isolated or successive action; stroking the ball of the thumb, for example, causes adduction of the thumb towards the palm; or stimulating the skin over the sterno-mastoid causes the head to assume the wry-neck position.

* Psychiatry, a Clinical Treatise on Diseases of the Fore-Brain. Translated by B. Sachs, M.D.

† Hypnotism or Animal Magnetism. Translated by L. C. Wooldridge, M.D.

A case reported by me in 1880,* is interesting in connection with this question. It was one of epilepsy clearly Jacksonian in type, and as clearly due to a fibroma involving a nerve trunk on the palmar surface of the hand. The patient, 15 years old, had had the seizures since the age of 4 years, they coming on after an injury to the hand at the situation of the fibroma. After removal of the growth, she had spasmodic attacks of the same type as before the operation, but less in frequency for a year, after which she rapidly improved, and I have been recently informed has had no spasms for nearly two years.

A description of the usual character of the attacks shows that they were distinctly Jacksonian. The description will be quoted at length because of the importance of the matter under discussion.

> The distal phalanx of the ring finger of the right hand was first flexed; secondly, a few spasmodic movements of flexion would occur in this finger; thirdly, the other fingers and thumb of this hand would begin to twitch convulsively—the second phalanges would be flexed, the last extended; fourthly, the clonic convulsive movement would extend to the right hand, forearm and arm, and simultaneously the muscles of the lower part of the right side of the face would become affected with spasm, a tremor also appearing in the tongue during this period: fifthly, the right arm and leg would now become affected with a clonic spasm, causing them to assume positions of flexion, the head, neck and body being drawn by the spasm at the same time to the right, a condition of pleurosthotonus being, in fact, produced. The seizures would pass off with a very severe jerking movement of the right shoulder, and a renewal of the twitchings of the muscles of the right angle of the mouth. These movements of the shoulder and mouth would sometimes occur only once, just before the close of the attack; more frequently, however, they would take place two or three times in succession. Occasionally the patient would bite her tongue during the paroxysms. She apparently was never entirely unconscious during the attack, no matter how severe it might be. During the height of the convulsion, if her hand was pressed too hard she would manage to gasp out, "Don't," or to make some other exclamation.

Unilateral Nervous Affections in Bright's Disease.

Considerable evidence has accumulated to show that affections of the nervous system, strictly limited to one-half of the body, occur during the course of some forms of Bright's disease. In this country Dercum† has reported cases of hemichorea, hemiplegia and unilateral convulsions. Raymond,‡ Chantmesse and Tenneson§ reported series

* Phila. Med. Times, December 18, 1880.

† Jour. Nervous and M. D., vol. xiv., No. 8, August, 1887, p. 473.

‡ Thèse pour le Doctorat en Médecine, 1878, Versailles, and Rev. de Méd., Sept. 1885.

§ Rev. de Méd., Nov. 1885.

of cases of unilateral affections, chiefly hemiplegia and epilepsy apparently of uræmic, or at least renal origin. In not one, according to the reporters, could the trace of a strictly focal lesion be discovered. Chaufford * reports a highly interesting case under the title of uræmic convulsions of the Jacksonian form.

Hystero-Epilepsy and Jacksonian Epilepsy.

Some cases which seem to be clearly forms of hystero-epilepsy closely resemble organic epilepsy of the Jacksonian type. Hystero-epileptic attacks, it is well known, can be produced by irritation of the hystero-epileptogenic zones, described by Charcot, Richer, and others, which are evidently analogous to the epileptogenic zones of Brown-Sequard.† Almost every form of spasm in localization and extent can be found in the descriptions of hystero-epilepsy. Features of distinction are, however, present. Undoubtedly one reason for the similarity between spasmodic affections reflex, hysterical, toxic and cerebral, lies in the fact that in these cases, whatever may be the starting point, central areas are discharged and give definite character to the convulsions. Horsley speaks of hystero-epilepsy as a cortical disease, but this view cannot be upheld for all cases, if he means by this that the spasms are usually the result of cortical discharge. They are rather sometimes bulbar or spinal, cortical inhibition being removed.

The difficulties of making a diagnosis between grave hysteria or hystero-epilepsy, and cerebral tumor or other organic lesion with apparent or real Jacksonian symptoms, is sometimes great, and was strikingly shown in a case seen by me in consultation with Dr. J. M. Barton, of Philadelphia. This patient, a married woman, 35 years old, came under observation in the spring of 1886. She had been in bed eight weeks, and had taken no part in her household affairs for several months. Her sickness began with complaints of headaches and feelings of slight numbness in the left hand and arm ; she would occasionally drop things from this hand. She soon developed analgesia and anæsthesia in the left arm and leg, and sometimes in the face ; this varied in severity. Her mental condition gradually changed, she became irritable, absent minded, and lacking in attention and judgment. She had at times hallucinations of sight, which usually occurred after lying down, these often taking the form of animals, as cats, mice, etc., disappearing around corners. Hearing was good in the left ear, but in the right was diminished ; careful examination showed no external or middle ear disease.

* Arch. Gen. de Méd., Paris, 1887, ii., 5–19.

† Lancet, Lond., 1886, ii., 1211–1213, Abstract of Brown Lectures.

She suffered almost continuously from headache, which she described as violent and agonizing, and which she localized mostly in the fronto-parietal region ; and a cranial area over the right motor zone was very tender to pressure and percussion. Nausea and severe vomiting came on late, and both headache and vomiting were accompanied by vertiginous sensations. A curious symptom was a constant diarrhœa, the patient having six to fifteen passages a day, and sometimes as many as twenty-four. She also often spat a bloody fluid from the mouth. Her appetite and sleep were much impaired, and she lost considerably in weight.

Ophthalmoscopic examinations made in March, 1886, by Dr. W. W. McClure, gave the following results : *Right eye :*—The pupil more active than the left ; media clear ; slight physiological cupping and venous pulsation ; no arterial movement observable. Slight choroidal change in pigmentation to the temporal side of the nerve ; outline of nerve above not defined, but merged with the retina. Macula good. Hypermetropia. *Left eye :*—Pupil more dilated and less active than in the right eye. Appearances much like those seen in the other eye, but worse. Evidences in color and margin of slow chronic inflammation. Macula good. Right eye, vision, $\frac{20}{60}$; left eye, vision, $\frac{20}{70}$.

After her illness had continued several months, the patient began to experience at times attacks of flexure of the fingers and thumb of the left hand, and cramp-like feelings in the forearm and arm. Later these spastic attacks began in the left foot, causing the great toe to be flexed upward and the other toes downward, with also some cramp feelings in the left leg.

A number of consultations were held with reference to this patient with Drs. J. B. Roberts and C. B. Nancrede, who took the view that the case was probably hysterical, and treatment was eventually suspended.

The patient's general health improved ; she gained in weight and attended to household and business affairs, never, however, getting entirely rid of her main symptoms, and recently some of these have returned with renewed vigor. She has fallen several times in public places and at her own home, appearing to become entirely unconscious. The attacks are preceded by a thrill passing up the left leg, and twitching of the left arm ; the latter continuing through the entire seizure and being the only muscular movement noticed.

Visual Localization.

Next to determinations of the motor zone visual localizations are the most conclusive, and this in spite of the hard-fought battles of the

physiologists over the cortical sight areas. Clinical medicine and pathology have here come bravely forward to clear away the storm. A few well reported cases of hemianopsia with autopsies, as those by Jastrowitz,* Haab,† Huguenin,‡ Monakow,§ Seguin,‖ Hun,¶ Fere, Keen and Thomson, seem to settle beyond doubt the connection of the cuneus and adjacent region with the retina and simple visual sensation.

Jastrowitz has recorded a case of paresis of the right leg, arm, and face, with a peculiar form of aphasia. The patient was unable to read and write connectedly; he could not understand written words. The history does not relate definitely whether or not he understood spoken words. Right hemianopsia was also present. The autopsy showed tumor of the left occipital lobe and precuneus.

Seguin, in a contribution to the pathology of hemianopsia of central origin, in many respects the most valuable publication on the subject which has yet appeared, collected forty cases with autopsies, and five traumatic cases without autopsies. Eleven of these were cases of hemianopsia due to lesions of the white substance of the occipital lobe. Sixteen were cases of cortical lesion, or of lesion limited to the cortex and the white substance immediately subjacent; and four of the sixteen (those of Haab, Huguenin, Fere, and Seguin referred to above) are what might be termed conclusive cases as to the question of the location of at least a portion of the cortical visual centre in man; as in them the lesion was circumscribed and occupied nearly the same place in the occipital lobe. They would, at least, seem to settle definitely that in the cuneus and its immediate neighborhood the visual half centre for retinal sensations is located. Owing to their importance I will give briefly from Seguin a condensed abstract of these cases.

Haab's case was a man, 68 years old who had an attack of temporary paresis of the left extremities. The patient complained that he could not see to his left with his left eye—though his right eye was normal. No anæsthesia; intelligence was normal, hearing good. Central vision—1 (H.2). There was left homonymous hemianopsia, the limit reaching quite (?) up to fixation point. In the right fields color perception was good. Optic nerves presented a "senile grayish color." The autopsy showed the extremity of the right hemisphere

* Centralb. für prakt. Augenheilk, vol. i., December, 1879, p. 254.
† Klinische Monatsblätter f. Augenheilk, xx., 141, 1882.
‡ Ibid.
§ Archiv f. Psychiat. u. Nervenkrankeiten, Bd. 16, S. 166.
‖ Jour. of Nerv. & Men. Dis., vol. xiii., No. 1, January, 1888, 1–38.
¶ Am. Jour. Med. Sci., vol. xciii., January, 1887, 140–168.

5 mm. shorter than its fellow and a depression in the right occipital lobe, the pia hanging loosely over a cavity containing clear fluid. The patch was mostly upon the mesial aspect of the hemisphere (including apex). It occupied the site of the fissure hippocampi, and extended beyond it above and below. The white substance was but slightly injured.

Huguenin recorded the case of a girl, aged 8 years, whose chief symptoms were headache in paroxysms; later, frequent vomiting, sleep broken; severe convulsions which frequently recurred; increasing dementia; slight neuritis with some swelling. It was noticed after some months that the patient held her head obliquely to the left. Examination revealed left homonymous hemianopsia, the only symptom indicating a focal lesion of the brain. The patient died of broncho-pneumonia. At the autopsy two tumors were found in the brain; one at the apex of the left frontal lobe. The second tumor lay in the mesial aspect of the right occipital lobe, projecting a few mm. above the level of the brain, firmly adherent to the pia and only slightly to the dura. Its length was 3 cent., height 3 cent., thickness 2.5 cent.—mostly buried in brain substance. It lay directly over the sulcus hippocampi, extending to either side of it. The base of the occipital lobe was not involved.

Fere reported the case of a female, aged 52 years, who in November, 1883, had a sudden apoplectic attack followed by right hemiplegia. She had partial and slight right hemianæsthesia to cold and pain. Hearing, taste and smell were normal; and typical right lateral hemianopsia, the vertical line passing through the point of fixation, was present. Autopsy showed a yellow patch destroying the greater part of the left cuneus and encroaching somewhat on the adjacent occipito-temporal convolution, the fifth temporal convolution of Ecker. No other lesions were present.

Seguin reports one personal case. The patient, a man 46 years old, consulted him first in January, 1884, for insomnia and dyspepsia. He was treated for various symptoms with varying success. December 5, 1884, he had an attack in which he complained of numbness in the left cheek, arm and face, and most marked in the hand and foot. He had no distinct hemiplegia, and no hemianæsthesia, but thought that tactile sensibility as in passing his fingers over objects, was somewhat duller. He could not see objects on his turning his head and eyes, and testing revealed left lateral hemianopsia, with a vertical division line not including the point of fixation. Central vision was good. He continued with varying symptoms until May 17, 1885, when he died. During his long illness he had attacks of acute hallucinatory

mania, both aural and hallucinatory illusions being present. He had chills, high fever, and sweats which followed no distinct periodicity. Previous to his death his speech was sometimes somewhat difficult to understand. The hands both showed disorders of movement, choreiform tremors, and in the left hand slight ataxia and larger motion. The hemianopsia persisted to the last unchanged. The central vision remained good. The brain lesion which doubtless caused the hemianopsia was found on autopsy to be a large focus of yellow of softening, evidently an old patch, involving the basal part of the cuneus, the fourth and fifth temporal convolutions of Ecker, and a part of the hippocampal gyre. Other lesions were present in the brain, but as this case was in harmony with others Seguin regards it very properly as of great value.

In his table in the paper referred to on cortex hemianopsia, Seguin has included five cases of traumatic hemianopsia due to injuries of the occipital region of the skull, and lesion of the subjacent brain. I will refer to only one of these cases, that of Keen and Thomson, which is of historical as well as of scientific interest. Through the courtesy of Dr. Keen, I have examined a cast of the head of this patient. The case was reported in the photographic Review of Medicine and Surgery, February, 1871 ; also in the Medical and Surgical History of the War of the Rebellion, Part 1, p. 206–207. It is also referred to in Flint's Physiology of Man, vol. v., p. 41–42, 1874, as one of the first cases to show that the filaments from the optic tracts on the two sides are connected with distinct portions of the retina. The patient was kept under observation off and on for a number of years, and was examined and exhibited by Dr. Seguin at the time of the reading of his paper. His hemianopsia was found unchanged twenty-three years after the reception of his injury. The patient died within a year or two, but unfortunately no autopsy was secured. He was hit on the head by a minie ball at the battle of Antietam, September 17, 1862. The wound of entrance was in the middle line 1¼ inch above the external occipital protuberance ; it made its exit about two inches to the left of the middle line, and three above the wound of entrance. He noticed impairment of vision two days after the injury. About ten days afterwards he had an attack of loss of consciousness with some paralysis of the right arm and right leg, which lasted some two or three months. His memory was imperfect for some months, but he had no aphasia. In walking he was very giddy, and noise and laughter would hurt him. His mental and physical powers gradually grew better. He was seen and examined by Drs. Keen and Thomson, in December, 1870. Among other conditions he was found to have a

complete lateral hemianopsia. Upon testing the field of vision it was found to be divided in each eye by a line passing through its centre in a vertical direction—total blindness existing to the right, and perfect vision to the left of this line. Ophthalmoscopic examination showed no pathological appearances. When Dr. Seguin examined this man in 1885, he presented no distinct paralysis, no anæsthesia, no aphasic symptoms. His tongue deviated a little to the right, and the grasp of the right hand was a little lighter than that of the left. A rough test with a small white object at 18 inches showed right lateral hemianopsia, with line passing outside of point of fixation, and a darkened area in the left upper temporal quadrant. Pupillary reaction was normal. Examination of the fundus showed blood vessels of normal size; outer temporal quadrant of each disc whiter than normal; left a little whiter than the right. An experiment on the cadaver showed that the track of the ball was such that it must have injured the optic fasciculus on its way to the cuneus.

The most important case which has been recorded since the paper of Seguin is that of Hun, in which a defect in the fields of vision involving the lower left quadrant of each eye occurred with atrophy of the lower half of the right cuneus.

The patient, a man aged 57, in 1869, had a severe attack of double pneumonia, and during the year following slight attacks of vertigo while walking, which were attributed to weakness. From 1877 until his death, he was troubled by slight deafness and by more or less roaring in his ears. In 1882 he had a large carbuncle on his neck, and after that time he seemed less vigorous than before. Early in December, 1884, he was examined by Dr. Merrill, who found normal reaction of the pupils, normal appearance of the fundus, vision and color perception perfect, but a defect in the fields of vision involving almost the whole of the left lower and the peripheral portion of the left upper quadrants in each field. The defect was somewhat more extensive, especially as regards the upper quadrant, in the left field of vision than in the right.

From this time the condition of the patient did not change materially. He continued to be very nervous, and at times irritable and suspicious. He exhibited no paralysis of motion or sensation. His memory was weak in regard to names; he often called the same person by several names in the course of conversation; while in other respects, as in recognizing faces, his memory was excellent. He slept but little, and in his sleep there was much twitching of the limbs. In 1885 he had a severe attack of angina pectoris, and for two weeks he could walk only a short distance without bringing on an attack of the pain. In

February, 1886, he had his most severe attack of angina, lasting several hours, and from this attack until his death, he was scarcely a day without pain in the precordia or in the arm. During the last month of his life he vomited often. He complained of increasing dullness of vision and of greater angle of obliteration, and was much troubled by a new building near by appearing to be out of line. On May 7, 1886, while quietly walking in the street he sank gently to the ground and died.

At a point on the median surface of the right occipital lobe was complete atrophy of the cerebral convolutions, only a trace of them remaining as a delicate gray gelatinous fringe. This atrophy was strictly limited to the lower half of the cuneus; being bounded below by the calcarine fissure, in front by the parieto-occipital fissure, and above by a curved line which started from the parieto-occipital fissure and arching backwards across the middle of the cuneus terminated at the posterior border of the median surface close to the calcarine fissure. The white matter underneath the point of atrophy was softened to a depth of about one-third of an inch. There was no deposit of pigment in the neighborhood. The corresponding point on the left occipital lobe showed no atrophy, nor did any of the other cerebral convolutions. Sections through the brain substance, the optic thalami, and the other ganglia at the base revealed nothing abnormal. The optic nerves and tracts showed no microscopic atrophy or degeneration. No microscopical examination was made.*

Views of Physiologists as to Visual Localization.

The view of Ferrier as expressed in the latest edition of his *Functions of the Brain*, is that the angular gyres maintain relations with the areas of clear vision, and as a matter of course especially with the macula luteæ.

This physiologist has modified his earlier views in so far that he no longer localizes the visual centres in the angular gyres to the exclusion of the occipital lobe; but believes now that the visual centres

* At a recent meeting of the Philadelphia Pathological Society, I presented the brain of a man who had been blind more than twenty-five years—how much more could not be positively ascertained. Both occipital lobes were unquestionably small. The cuneus on each side was small, the first occipital convolution of Ecker (superior external pli de passage of Gratiolet, and par-occipital of Wilder) showing lack or arrest of development. The second and third occipital convolutions of Ecker, especially on the left, presented a narrow, dwindled appearance. In another brain of an old woman, blind for at least thirty years, similar gross appearances of arrested development in the occipital region were present.

embrace not only the angular gyres, but also the occipital lobes which together he terms the occipito-angular regions.

Recently considerable activity has been exhibited in the investigation of visual centres.

From a long series of experiments upon the monkey's brain, on which he was engaged with Mr. Victor Horsley during more than two years, Schäfer* writes as follows :

"With regard to vision our experiments were not conclusive. We found that extensive lesions, both of the occipital lobe and of the temporal lobe, were invariably followed by visual disturbances, taking the form, when the operation was confined to one side of the brain, of bilateral homonymous hemianopsia ; but in nearly every case the hemianopsia was merely temporary, and after a certain time we could not in our monkeys obtain any distinct evidence of the persistence of the visual defect. The most marked results of this kind were obtained when the occipital lobes were the seat of the operation, extensive unilateral lesions in this region producing hemiopia, and bilateral lesions producing amblyopia ; but in neither case were the symptoms permanent, and after a time the animals, so far as we were able to determine, could see as well as their intact fellows. In one case only did the hemiopia persist, and this was one in which, after a bilateral lesion of both occipital lobes had been carried out and the temporary blindness thereby produced had been recovered from, the angular gyrus of one side was destroyed. This second operation, made upon the animal in which the occipitals had already been extensively destroyed *without* permanent blindness, did produce a condition of hemianopsia which lasted until the animal's death some three months later. We were of opinion at the time that this instance might warrant us in taking up a position similar to that of Luciani and Tamburini, and intermediate between those of Ferrier and Munk—the former of whom originally denied the participation of the occipital lobe in the visual perceptive function, and still appears to regard it as subordinate to the angular gyrus ; whereas the latter would localize those perceptions entirely in the occipital lobe, and deny all participation of the angular gyrus. But we made only four experiments upon these regions, and in none of them was the removal of the occipital lobe complete, as was proved by post-mortem examinations of the brains. They were not, therefore, decisive against Munk's statement, that persistent hemiopia or blindness follows extirpation of one or both occipital lobes alone, and it became necessary to pursue further inquiries in order to test its accuracy."

In conjunction with Dr. Sanger-Brown, Schäfer also experimented upon the angular gyre and upon the occipital lobes. Destroying one angular gyrus as completely as possible with the actual cautery they could discover no defect of vision, no loss of movement of the eyes or eyelids, and no anæsthesia of the corneal conjunctiva. A week later the angular gyre of the opposite was destroyed, also with negative results.

* Brain, London, January, 1888.

In illustration of the effects produced by complete removal of the occipital lobe, and that alone Schäfer gives two instances, in one of which the operation was unilateral, in the other bilateral.

"In the monkey upon which the unilateral operation was performed, the left occipital lobe was removed by a vertical incision carried along the line of the parieto-occipital fissure. That the removal was exact and complete was confirmed on post-mortem examination, some eight months after the establishment of the lesion, when it was seen that the whole of the occipital lobe, and only this lobe was involved, the angular gyrus being quite intact and normal, and the surface of the section looking as fresh, and showing as clearly the distinction of grey and white matter, as if the operation had just been performed. The result was the immediate establishment of bilateral homonymous hemianopsia, which persisted the whole time the monkey was kept alive. Objects so placed that their images fell upon the left half of the retinæ were taken no notice of: a threatened blow coming from the right-hand side of the mesial visual plane was winced at or avoided; currants strewn upon the floor were only picked up towards the left side, the animal working in that direction. In the case of the monkey with bilateral operation the result was total and persistent blindness."

The views of Hun* are that the convex surface of the occipital lobe, particularly of the left side, is associated with complete visual perception and recognition; and also that the so-called left angular gyre is essential for the memory of the appearance of words, lesions of it causing alexia and agraphia.

I shall not attempt to analyze, criticise or reconcile these various and varying views. They agree, at least, in showing the production of hemianopsia from lesions of the cuneus and adjacent occipital lobe.

The general visual zone, which has been determined can probably be compared as to subdivision with the general motor zone. As the motor zone has been subdivided into areas of representation, not only for the leg, trunk, arm, face and speech, etc., but also into areas or centres for parts of the leg, arm, face and speech, so efforts, partly successful are now being made to subdivide the visual zone. The retina so far as its connection with the central cortex is concerned, can be subdivided into segments probably of a somewhat regular shape. At first studies in hemiopia and hemianopsia seemed to show that the only definite connection was between the halves of the retinæ and cortical centres, but the latest observations indicate that quadrants, and probably even smaller portions of the retinal expansion are related to separate areas in the brain. The macular region almost certainly has its special cortical centre. The tendency of investigation, both experimental and pathological, is to show that the whole of the occipital lobe, and adjoining portions of the parietal and temporal lobes,

* Op. cit.

are in some way concerned with vision, as I have tried to indicate in the diagram (Fig. 6).

With reference to visual localization, the importance of confirming physiological experimentation by careful clinico-pathological observations cannot be overestimated ; these observations are here even of more importanoe than in motor localization. The movements of a limb or a portion of a limb, can be studied with considerable accuracy in the lower animals as well as in man ; but in investigating sight, the other special senses, or general sensibility, in the lower animals, we are confronted with special difficulties and sources of error. This is perhaps more strikingly true of hearing, taste and smell, than of the other senses but it is true for all. Schäfer referring to a monkey from which he believed he had eradicated both angular gyres, states that for three or four weeks the animal failed to see objects which were just below or to one side of its eyes, and even at the time of writing there appeared to be complete absence of vision in the antero-superior and lateral portions of the retinæ ; but it was difficult to prove this because the monkey had acquired the habit of rapidly directing his head and eyes so as to use the central parts of the retinæ.

Operations guided by Visual Localization.

In spite of the conflict of views with reference to visual localization, sufficient has been determined to indicate several positions for operation guided chiefly by visual symptoms.

If a patient has lateral homonymous hemianopsia as the special localizing symptom, operation should be performed with the view of reaching the cuneus behind the position of the parieto-occipital fissure. If, without hemianopsia, the patient fails in intelligent recognition of things and words, the aim should be the lateral occipital convolutions and the angular gyre, which is adjacent, or indeed may be situated in the occipital lobe. When, with lateral homonymous hemianopsia, the patient also has hemianæsthesia, the lesion is probably in the tracts between the cuneus and the primary optic centres, large enough also to involve the sensory tracts. Such a lesion would probably best be reached beneath the position where, on the lateral aspect of the hemisphere, the parietal, occipital and temporal lobes come together. Hemianopsia is sometimes a late symptom, the result of invasion of the visual region from other localities ; such a case will be referred to later when speaking of large lesions of the temporal lobe.

I have made various examinations of the human brain on recent as well as older specimens in order to determine, if possible, where the optic radiation proceeding from the corpora genticulata and corpora quadrigemina enter the hemisphere to proceed to the cortical centre of vision ; in part with a view of determining the relations of the angular gyrus, cuneus, and adjoining occipito-temporal region to this place of entrance, and therefore the position and direction of the intra-cerebral tracts. Undoubtedly, so far as the human brain is concerned, both the angular gyrus and the occipital lobe are so placed with reference to the geniculate bodies and corpora quadrigemina that they are anatomically and morphologically in relation with these radiations. Schäfer * gives a view of a longitudinal section of the hemisphere of a monkey which he believes demonstrates that fibres proceeding to the angular gyrus are not involved in lesions of the occipito-temporal regions. Whatever may be true of the monkey, this is certainly not true of the human brain.

Wernicke's Hemiopic Pupillary Inaction.

The great practical importance of some of the studies which have grown out of cerebral localization is seen in the fact that the simple but valuable discovery in semiology, Wernicke's hemiopic pupillary reaction, enables us with a flash of the ophthalmoscope to throw the lesion producing hemianopsia back of the primary optic centres. With a normal retina uniform pupillary reaction occurs no matter at what position the ray of light strikes upon it. Seguin † clearly explains this hemiopic pupillary reaction, or inaction, as he suggests to call it, in one of his papers on hemianopsia. In a word, the test depends upon the fact that the hemiopic part of each retina being physiologically inert, fails to receive any impulse from the light which is thrown on it. When the lesion is in the cuneus or occipital lobes, hemiopic pupillary reaction is not observed. When the lesion, producing hemianopsia involves the optic tracts, there is from an early period hemiopic pupillary inaction as well as partial nerve atrophy. A full discussion of this subject will be found in the paper of Seguin, and the original memoir of Wernicke.

* Brain, July, 1888.

† Jour. of Nerv. and Ment. Dis., vol. xiv, November and December, 1887, 721–737, and Fortschritte der Medicin, I. Heft 2, 1883, cited by Seguin.

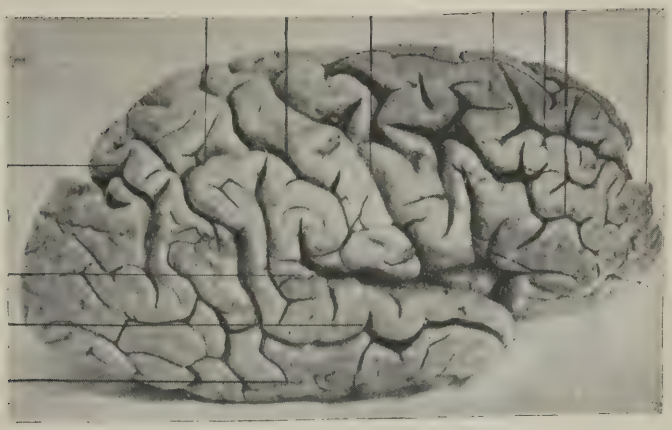

Fig. 8.—Brain of Delusional Monomaniac.

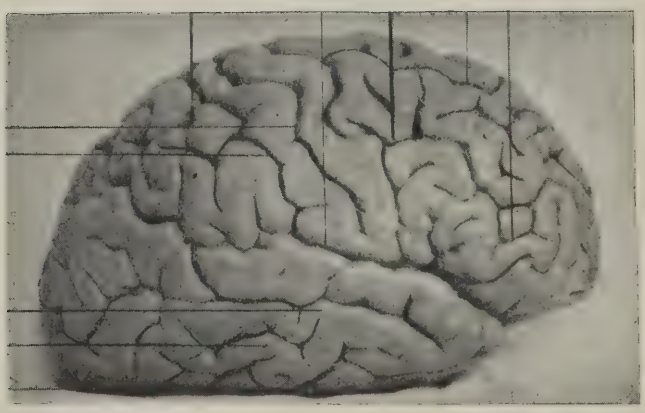

Fig. 9.—Chinese Brain.

Morphological Peculiarities of the Human Brain.

It is a question whether we are in a position for practical purposes to make any distinction between the angular gyre and the external occipital convolutions ; nor is it absolutely necessary that this should be done in trephining with a large instrument.

Morphological peculiarities of the human brain have an important bearing on this subject. In 1880,* I called attention to this matter and particularly with reference to the so-called angular gyre, referring to the brain of a white man in which the first temporal sulcus extended back of the transverse occipital and to within half an inch of the longitudinal fissure. The angular gyre is usually regarded as the arch composed of the posterior uniting portions of the inferior parietal and superior temporal gyres. It has seemed to me that these morphological aberrations are especially marked in the parieto-occipital region, so much so in some cases as to lead us to use great care in determining by external methods the position of the cerebral areas.

It will only be necessary to call attention to one or two striking peculiarities in the brains examined, mostly in the insane and in individuals of low organization.† In a case of delusional monomania, for example, the occipital fissure showed itself and in its communications and surroundings, marked ape-like conditions, such as might have been very deceptive if exposed by trephining (Fig. 8).

In the other hemisphere of the same case the cuneus was small, and the first temporal fissure presented an unusual appearance, being divided about its middle by a comparatively large gyre. In another case, in the right hemisphere, the second temporal fissure was short, and communicated with a very well defined almost vertical fissure, which separated the temporal from the occipital lobe. The first temporal, as well as the second, communicated with this fissure, the vertical extension of the first being, in fact, continuous with it. The cuneus was distinctly smaller and of a different shape from the cuneus of the right hemisphere. In another case, the first temporal fissure was remarkable in that it was completely confluent with the Sylvian, extending from the point of the confluence as a deep, well defined trench backwards and upwards nearly to the sagittal fissure, crossing and confluent with the interparietal. In a Chinese brain (Fig. 9) studied by Dr. A. J. Parker and myself, a remarkable peculiarity of the brain was that in the right hemisphere the first temporal fissure, beginning near the anterior extremity of the temporal lobe, passed

* Phila. Med. Times, April 24, 1880, 366–370.

† Jour. Nerv. and Ment. Dis., vol. xii., September and October, 1886, 517–553.

backward across the entire extent of the parietal lobe and over the median edge of the hemisphere for the distance of half an inch, terminating in the precuneus just in front of the parieto-occipital fissure.

This is an interesting field, and has some practical importance. Even the Sylvian, the central, and the parieto-occipital fissures, have considerable variations, the first in its horizontal level and extension, and the others in their antero-posterior position. I have reported one case in which the Sylvian fissure took a position much more vertical than usual and reached nearly to the longitudinal fissure. As a rule, variations, such as those referred to here, for fissures like the Sylvian, would not confuse us in operating after the methods of Broca, Thane, Reid, Horsley, and others ; but they are certainly worthy of some consideration.

Localization of Cutaneous Sensations.

With reference to the localization of the centres for cutaneous sensations—touch, pain, temperature, etc.—we are acquiring more positive knowledge and may be able in time to use such knowledge to guide in surgical operations. The evidence, physiological, clinical, and pathological is becoming stronger in favor of the existence of a zone for these general sensations separate from the motor areas.

Various, indeed, have been the views held with reference to the localization of these sensations. Luys, largely from anatomical studies, made the thalamus a centre of sensibility, subdividing it into four special centres—olfactory, optic, acoustic, and for general sensibility. Ferrier, regards the thalamus as in some way connected with sensation, but believes that differentiated areas for sensation also exist in the cortex. He holds that it is probable that the thalami are especially related to the sensory tracts, and the striate bodies to the motor tracts ; that these ganglia represent in a subordinate manner all the sensory and motor tracts of the cortex. The thalamus is a centre of conveyance, or an interrupting ganglion in the course of the sensory tracts. The experiments of Monakow led to the conclusion that different portions of the thalamus are related to cortical areas. Fournier believes that sensory fibres terminate in the thalamus. Crichton-Browne regards this ganglion as a great centre of general sensibility ; but Flourens, Longet, Schiff, and Tamburini, among others, have assigned to it motor functions. The weight of the evidence both from experiment and disease connects the thalamus with various forms of sensation. It is probably a halting place where sensory impressions going from the periphery to the cortex undergo some transformation. It is nec-

essary, at least, briefly to thus refer the functions of the thalamus as some authorities are inclined to regard it as the sole cerebral region for sensibility.

From analogy and general principles it is altogether probable that we have above the ganglia a separate localization for the different forms of cutaneous sensibility. As Ferrier puts it, up to the point of radiation towards the cerebral cortex the sensory paths have been proved to be entirely differentiated from the motor, and it is therefore extremely unlikely that the two should become jumbled together indiscriminately in the cortical centres. We have not only the well known differentiation between sensory and motor nerve roots and tracts in the spinal cord, oblongata, pons, and crus cerebri; but abundant evidence as to the separation of sensory from motor tracts in the internal capsule. The very simple but natural question may be asked: where do these paths lead if not to special cortical areas for sensation? Cases have been reported by Demeaux (quoted by Ferrier), by F. Müller and others, in which autopsies have shown hemianæsthesia to result from lesion of the hinder third of the internal capsule or adjoining portions of the corona radiata.

Veyssière produced hemianæsthesia on the opposite side of the body by dividing this portion of the capsule in animals. We not infrequently see hemiplegia and hemianæsthesia united in the same patient as the result of a capsular lesion, and numerous autopsies have shown that the posterior and middle parts of the capsule are in these cases involved in a destructive lesion. Cases of hemianæsthesia from lesions both of the thalamus and lenticular nucleus have been reported, but in very few has the lesion been strictly localized to these ganglia, and even in these it is a question whether the hemianæsthesia resulting has not been due to pressure on the internal capsule.

Recently I made a post-mortem examination on a patient who died at the Philadelphia Hospital, a woman 47 years old. She had had many symptoms which were supposed to be hysterical. On the morning after her admission she had a fit or seizure, the character of which was not closely observed. Afterwards, however, she was paralyzed and anæsthetic over the right half of the body and limbs, her speech also being thick, but consciousness not lost. Partial anæsthesia was present over the left half of the body. Knee-jerk was increased, and ankle clonus was present on both sides. She improved rapidly but remained in bed two weeks. Two days before her death she had an apoplectic attack and became completely paralyzed and hemianæsthetic in the face, limbs, and trunk of the left side. The autopsy showed a

foyer of softening in the right hemisphere, including the entire breadth of the internal capsule, two-thirds of the adjoining lenticular nucleus, a small anterior external portion of the thalamus, and a narrow strip of the caudate nucleus where it curves around the thalamus. Careful transverse sections showed that the anterior boundary of this focus of softening was 1¼ inches behind the head of the caudate and lenticular bodies, and that it extended from before backwards about ⅝ of an inch. It was so situated that a transverse section immediately in front of the thalamus marked its anterior boundary. The softening of the narrowed caudate nucleus was all that was observable in opening the ventricle. The left hemiplegia and hemianæsthesia might very properly be attributed to the complete transverse destruction of the internal capsule. A large recent embolus was found in the right middle cerebral artery. It is difficult to account for the temporary right hemiplegia and hemianæsthesia, except on the theory of hysteria or functional disturbance, as no lesion of the cerebral hemisphere on the left side was discovered.

The fibres of the sensory tract are probably separate from the motor even in the centrum ovale.

"The third set of fibres of the projection system," says Starr,* "includes those which lie just posterior to the motor tract, and which pass inward from the parietal convolutions. These take a similar course to those of the motor tract, and fill up to a considerable extent the space between it and the radiation of the visual tract, toward the occipital lobe. They are mingled with fibres which pass to the optic thalamus, but are separable from them, as Edinger has shown, in fœtal brains, and may be traced down through the capsule to the tegmentum of the crus, where they divide into a portion going to the leminscus, and a portion going to the formatio reticularis. This set of fibres conveys the sensations of touch, pain, temperature, and muscular sense, and lesions in its course will cause disturbance of these sensations. Like lesions in the motor tract, the rule obtains that the nearer the cortex the more likely is the lesion to cause an affection of a single limb, while the nearer the capsule the more likely is the symptom produced to be hemianæsthesia."

Ferrier in his earlier experiments found that lesions involving the horn of ammon and hippocampal convolution caused impairment or abolition of tactile sensibility on the opposite side of the body, and located the cortical centres for this form of sensibility in the hippocampal region. In experiments with Professor Yeo, in 1884, he established lesions in the hippocampal regions in ten monkeys, and in

* Medical Record, Feb. 13, 1886.

five of these in both hemispheres, and these lesions showed that tactile sensibility was in every case impaired or abolished, according to the amount of destruction of the hippocampal and temporo-sphenoidal region. It was also established, however, that a very extensive lesion might be made in one or both hippocampal regions without producing permanent anæsthesia.

Munk* claims that the area of common sensation—including sensation of pressure, location of a limb, muscular sense, and touch—lies in the central region, including the anterior and posterior convolutions and adjacent cortex. He divides this area into special centres for the hind leg, fore leg, head, eye and ear muscles, neck and body; holding that these coincide with but are somewhat more extensive than the corresponding motor centres for these parts.

The sensations of touch, according to Luciani, are perceived in the central convolutions, and therefore lesion of these cause anæsthesia as well as paralysis. The tactile area includes the parietal convolutions also, but does not reach the occipital and temporal lobes. This author holds that all sensations appear to have a common zone in the parietal region, and lesions in this common zone may cause disturbance of all the senses.

It is worthy of remark that the physiologists and others, who contend that the sensory portion of the cortex coincides with the motor, also hold that it extends beyond into adjacent cortical regions, as witness the views of Munk, Tripier, Moeli, and others, cited by Starr in his elaborate paper.

Ferrier's explanation† of what he regards as the errors of observers like Schiff, Munk and others who believe that sensory areas coincide with motor centres, is reasonable. "The conclusion that tactile sensibility is lost or diminished after the destruction of the cortical motor area," he says, "is based on defective methods of investigation and erroneous interpretation of the reactions of the lower animals to sensory stimulation. Though an animal does not react so readily to sensory stimulation of the paralyzed side it does not follow that this is due to diminished or absent perception of the stimulus. An animal may not react, or react less energetically, to a sensory stimulus, not because it does not feel it the less, but because it is unable or less able, to do so from motor defect. It is astonishing what apathy or indifference some animals display towards certain forms of stimulation, such as gradually increasing pressure on the fingers or toes

* Pfluger's Arch. f. Physiologie. Quoted by Starr, Jour. Nerv. and Ment. Dis., vol. xi., No. 3, July, 1884, 327–407.

† Functions of the Brain.

which one would regard as well calculated to elicit reaction or signs of uneasiness. Unless the stimulus is of a nature to at once excite attention, or to evoke reflex action, it may appear to be altogether unperceived. All that the experiments of Schiff and Tripier demonstrate is that motor reactions are less readily evoked on the side opposite the cortical lesion. But the same thing occurs in cases of purely motor hemiplegia in man."

On anatomical and morphological grounds Broca holds that the callosal and hippocampal regions constitute together a distinct lobe of the brain, the falciform or limbic lobe; also I believe erroneously, that this lobe is connected entirely with the sense of smell. So far as the brain of man is concerned, in this lobe should probably be included the entire precuneus or quadrate lobule on the mesial aspect of the hemisphere and the adjoining portion of the superior parietal convolution on the lateral aspect of the hemisphere.

The most important recent contribution to cortical sensory areas, is certainly that of Horsley and Schäfer.* Hemianæsthesia, partial or complete, and contra-lateral, resulted from destructive lesions of the limbic lobe. They found that any extensive lesion of the gyrus fornicatus was followed by hemianæsthesia more or less marked or persistent; sometimes the loss of sensation involved almost the whole of the opposite side of the body; sometimes it was localized either to the upper or lower limb, or to a particular part of the trunk. They did not, however, succeed in establishing the relations between special regions of the body and the parts of the convolutions which had been destroyed.

"These experiments were frequently, but by no means in every case, complicated by the presence of a certain amount of motor paralysis, chiefly, if not entirely, affecting the muscles of the leg. We have no doubt that this condition was always due to a lesion (accidentally produced during the operation, or subsequently, as the result of interference with the circulation) in the leg-area of the marginal convolution. Now in one or two of these cases the anæsthesia affected chiefly the paresed limb, and it might be argued by those who, like Schiff and Munk, hold that the excitable areas of the cortex are concerned with the perceptions of sensory impressions from the corresponding regions of the body that the loss of sensibility was due to lesion of the motor-area. But against this argument we may not only put forward those experiments in which there has been no accompanying paralysis, but also others in which the hemianæsthesia has been well marked in the upper limb and upper part of the trunk, while the lower (paresed) limb has exhibited no diminution of sensibility whatever." * * *

* Phil. Trans. Royal Soc., 1888.

"From which it would appear that while the whole limbic lobe may be concerned in the perception of sensory impressions, the part played by the gyrus fornicatus, at least, as regards cutaneous sensibility, is more important than that played by the hippocampal portion of the lobe. But until it has been possible entirely to destroy the whole lobe upon both sides of the brain it is impossible to determine whether it is assisted in its functions by any other portion of the cerebral cortex." * * *

"The results of our experiments upon the limbic lobe seem to point to the conclusion that this portion of the cerebral cortex is largely, if not exclusively, concerned in the appreciation of sensations, painful and tactile. This is an extension of the view put forward by Ferrier, who was inclined as the result of his own experiments, to limit that function to the hippocampal region. Dr. Ferrier was good enough to assist at some of our experiments upon this part, and has fully accepted the conclusions to which they point."

Starr, from a series of American cases of cortical lesions of the brain,* and also from a study of the sensory tracts,† concluded that the various sensory areas lie about and coincide to some extent with the various motor areas for similar parts; that, in other words, the Rolandic region is a sensory-motor region, the sensory area, however, including to some extent the gyres of the adjacent postero-parietal lobe. Collections of cases such as these cannot, however, overcome positive evidence of decided destructive lesions of the cortical motor centres, without any disturbance of touch, pain or temperature, or even of the muscular sense; and a close study of the cases of cortical lesion in which both motor and decided sensory phenomena have been present, will not bear out fully the view of Starr.

One of Starr's tables contains 41 cases showing cortical lesions of the brain with sensory symptoms. That the sensory area lies about the motor region might even from these cases be conceded, but that the two coincide has been by no means proved, particularly if the postero-parietal region is not regarded as a necessary part of the motor area. Reviewing the 41 cases, in only one-fifth to one-sixth are the lesions restricted to parts of the brain in front of the central fissure, although in many of the others both the anterior central and posterior central gyres are involved. In more than 30 of these cases the reported lesions involved in part or whole the postero-parietal region, and posterior central gyre. Four of my cases are included in the table, and this has led me to look over not only these but also

* Am. J. M. Sc., Phila., 1884, n. s., lxxxvii., 366–391.

† Jour. Nerv. & Ment. Dis, vol. xi., No. 3, July, 1884, 327–407.

other of my cases of cortical lesion with sensory phenomena ; and from doing this the conclusion has been reached that they do not support the doctrine that sensory and motor areas entirely coincide.

In the case of a fibroma which involved the first and second frontal gyres, and anterior segment of the gyrus fornicatus and corpus callosum, anæsthesia of the conjunctiva, with conjunctivitis and corneitis were present. In a patient with a gumma involving the upper fourth of the pre-central and a smaller segment of the post-central gyre, hyperæsthesia was marked, with also crural Jacksonian epilepsy, but the lesion grazed the sensory area. A carcinoma of the middle portion of the posterior central gyre and the upper part of the inferior parietal lobule was accompanied with wide-spread destruction of the corona radiata, and impaired sensibility of the limbs of the opposite side with other phenomena was present. Owing to the posterior extension of this growth and the large sub-cortical destruction, this lesion could certainly not be claimed to teach anything with reference to the coincidence of motor and sensory areas. In another case of tubercular tumor in the motor area, the interior of the hemisphere was broken down, and hemianæsthesia, at first partial but later complete and persistent, was present.

Numerous observations have shown me that hyperæsthesia is a common phenomenon in cases of diffused cortical tubercular meningitis, and this hyperæsthesia may involve any or all the extremities or the face. This fact is not to be explained as simply from irritation of the pia mater ; for, on the other hand, I have observed cases of localized lepto-meningitis in which both hyperæsthesia and even pain in the head were absent. Such cases also cannot be fully explained by tubercular deposit in and inflammation of the dura mater. Although dural meningitis may cause headache of great severity and sensory phenomena in the domain of the fifth nerve, it should not be held responsible for hyperæsthesia of the extremities. The hyperæsthesia in these cases is best explained by irritation of sensory cortical areas.

Bernhardt * has recorded the case of a woman, 41 years of age, who after an apoplectiform attack had hyperæsthesia of both lower extremities ; also paresis of the right arm, lower face, and foot; spasm involving the right hand, arm, and face ; weak reflexes of the right leg ; confusion, excitability and aphasia. The lesions were a tubercular growth in the upper extremity, lateral and median portion of the left posterior central convolution and in the precuneus ; a similar growth in the middle portion of the posterior central gyre ; and a tuber-

* Arch. f. Psych., iv., Heft 3, 1874.

cle the size of a pea at the anterior extremity of the corpus striatum. The hyperæsthesia in the lower extremities might be explained by the tumor in the great median fissure. Hitzig* quotes from Löffler, the account of a soldier who received a gunshot wound on the top of the head, the dura mater being pressed inward by the depressed bone at a point which corresponded with the upper ends of both central gyres. Both legs were hyperæsthetic and also paralyzed. Such symptoms can be explained by pressure on the paracentral gyres of both sides, and direct or inflammatory irritation of the neighboring sensory cortex below or behind.

Bramwell† has reported a case of incomplete paralysis of the left extremities and of the face, with disturbance of sensation of both the arm and leg ; with also atrophy of both optic nerves and other sight disturbances. The autopsy revealed a tumor with softening of the surrounding brain in the right superior and middle parietal convolutions, and a part of the first occipital convolution.

Brill‡ records the history of a patient with right-sided anæsthesia and paresis, the former more marked than the latter. In a few weeks hyperæsthesia developed, with also restlessness, tinnitus, beclouded mind, slight amnesic aphasia, and color blindness, the patient not being able to tell green from red, although his field of vision was not limited. A triangular focus of softening was found in the left cuneus, most of the cuneus being involved.

Fortunately I had the advantage a few hours before delivering this address of hearing one of the best papers yet written on the cortical localization of cutaneous sensations, read by Dr. C. L. Dana before the American Neurological Association, and since published in the Journal of Nervous and Mental Disease for October, 1888. Dr. Dana discusses the three views with reference to this localization : (1) That the centres for these senses are entirely separate from motor areas. (2) That the cutaneous sensory centres are more or less identified with the motor centres ; and (3) That both the motor zone and the limbic lobe are concerned in the representation of cutaneous sensation. His paper deals principally with pathological and clinical data. Altogether he collected 142 cases, including four personal observations. He concludes, among other things, that the clinical and pathological evidence collected by him shows that the motor areas of the cortex contain also the representation of cutaneous sensations ; and that cutaneous anæsthesia of organic central origin is always limited to or more pronounced in certain parts. The same objections apply to most of his cases as indicated for those of Starr.

* Op. cit.

† Lancet, September 4, 1875, ii., 346.

‡ N. Y. Med. Record, vol. xxii., 1882, July 15, 81–82.

Dana collected for this paper 20 cases in which the gyrus fornicatus or hippocampal convolution were more or less involved, and in none of these, he says, was any anæsthesia present that could be fairly attributed to the lesion. Even a casual study of these cases seems to me to show their weakness for the support of the position taken that the limbic or falciform lobe is not concerned with sensation. In nearly one-third of these cases some disturbance of sensation was present. Three of the remaining cases were demented, and presumably any investigation into cutaneous sensation would have but little value; one case presented no symptoms.

What Ferrier says of defective methods of investigation and erroneous interpretation of the reactions of the lower animals to sensory stimulation may be applied with some additions to the study of cutaneous sensation in cases of cerebrel disease in man. Numerous sources of error are present, not only in investigating but also in reporting the results of investigation.

To test cutaneous sensibility requires time, patience, and method. It is often tedious and monotonous; but it must be done carefully or the results, particularly for tactile sensibility, are worthless. Patients cannot often be depended upon, as with reference to such tests the greatest differences in the personal equation are found. Some patients have a fashion of stopping to think or weigh their answers when being tested for cutaneous sensation. This often renders the answers worthless; the response should be given promptly.

One of the commonest methods of investigating cutaneous sensibility is that of Weber, which depends upon the fact, or the alleged fact, that the distance apart at which two points can be discriminated is much the same for the same local areas in different individuals. Tables have been published which are supposed to show the least normal distances at which two points can be distinguished. This method, if very carefully applied, is sufficiently correct for many cases, but often the results obtained from such testing are utterly worthless. I have known not only patients with real or alleged loss of sensation, but perfectly healthy individuals to give diverse and confusing answers when tested with the æsthesiometer. Some of the records of the presence of anæsthesia or analgesia in reported cases have doubtless been made improperly as the result of carelessly testing the power of the patients to discriminate between two blunt or sharp points.

Another source of error, particularly in recording cases, is in deciding that objective insensibility exists from the statements of the pa-

tients with reference to their feelings. Whatever may be the explanation, it is true that many, though by no means all, patients suffering from motor paralysis the result of a cortical or sub-cortical lesion, complain of certain parasthesias. Spontaneously, or in response to questioning, they will refer to a paralyzed member, or a portion of it, as feeling heavy or numb, or cold, or as if asleep ; but often in these cases careful and elaborate testing for true depression or loss of sensation will fail to reveal its presence in the slightest degree. I have been for some time engaged in minutely studying cases of hemiplegia, monoplegia, and aphasia with a view of determining in the most detailed manner the exact movements, or forms of speech, impaired or abolished, and also whether or not in these cases localized defects of sensation were present. The investigation is a clinical study in localization, the value of which will be much enhanced by the number of autopsies obtained in the cases studied, but even without such autopsies some results both curious and valuable can be obtained. A single case will serve to illustrate the point which I wish to make about some sensory investigations and records. A young man, with a history of rheumatism, and several heart murmurs, was admitted to the Philadelphia Hospital three weeks after a sudden attack of right-sided hemiplegia with aphasia. On admission he had recovered almost entirely from the paralysis of the arm and leg, but decided facial paralysis and slight aphasia, or rather ora-lingual paresis, were still present. His motor symptoms were studied with minuteness and will be published in a paper in course of preparation. On inquiring as to sensory disturbance he said that he had had for several days some pain in the leg and arm, and a feeling of numbness or as if the parts were asleep, in the right face, arm and leg. This sensation had disappeared entirely from the leg and arm with the abatement of the motor paralysis, but he still complained of decided numbness in the right cheek. The most careful tests were made as to the senses of touch, pain, and temperature, but not the slightest loss could be determined. He was examined by gently touching the cheek with the finger and a feather, with blunt and sharp points, with hot and cold water, with different weights and different amounts of pressure, and by the method of Oppenheim, namely, that of touching symmetrical spots on both sides of the median line at once, and observing whether he appreciated the touch on both sides equally.*

* The patient recently died. At the autopsy, a focus of strictly cortical, yellowish softening was found involving the lower extremities of the central convolutions both on their external and Sylvian surfaces, and a spot one-half an inch in diameter about the middle of the internal portion of the island of Reil. The softening reached into the

Some light has been thrown on the disputed question of the existence of sensory centres in the motor cortex by careful examinations of patients after operations, particularly when definitely determined gyral areas have been cleanly excised. In one of Horsley's cases, in which the scar tissue and surrounding healthy brain substance was excised, after the operation the patient had at first, coupled with some motor paralysis, a loss of tactile sensibility over the dorsum of the two distal phalanges of the fingers, and could not tell the position of any of the joints of the fingers, thus showing apparently some loss of tactile and muscular sense ; but as Horsley remarked it was possible that some of the fibres of the corona radiata coming from the gyrus fornicatus may have been injured. Both motor and sensory paralysis disappeared in the course of two months.

In Weir and Seguin's case of right-sided Jacksonian epilepsy and paresis—in which a small sarcomatous growth was cut out of the white substance below the posterior edge of the second frontal, and the anterior edge of the pre-central gyres—careful tests were made over a period of nearly seven months after the operation. They showed at first slight apparent dulness of tactile sensibility in some parts ; retention of pain, and temperature, and muscular sense, with motor paresis and speech defect. In later tests the patient no longer felt numb ; could tell the lightest touch on the fingers and hand ; and with eyes closed could distinguish consecutive contacts with a coarse bed cover, a thin handkerchief, and a sheet of paper ; he could also recognize slight difference of weight. Nearly seven months after the operation co-ordination of the hand was perfect ; the patellar reflex normal and equal on both sides; there was no wrist reflex ; the senses of touch, temperature normal ; he could distinguish differences of weight of only a few grains, and was fully conscious of all passive movements.

In the case of Lloyd and Deaver, also one of brachio-facial spasm and paresis, reported at the meeting of the American Neurological Association during the session of the Congress, no gross lesion was found, and the facial and arm centres were carefully excised, with a resulting cure of the spasms. On several occasions, with Dr. Lloyd, I tested the conditions as to motor power, sensibility, and the reflexes in this patient, with results which have been reported by Dr. Lloyd.

fissure of Rolando, and also into the precentral fissure, taking in a posterior, inferior strip of the second frontal convolution. Its greatest height was 1½ inches upward from the Sylvian fissure, its width along this fissure was 1¼ inches. The lesion did not reach to the anterior branch of the Sylvian fissure, its anterior limit being one-fourth of an inch behind this fissure.

This patient blindfolded could instantly recognize the slightest touch on all points of the affected side ; even light breathing upon his hand was at once detected ; pain and temperature sense were normal ; and he could discriminate between weights. If objects were placed in his paretic hand he often failed to recognize what they were, but apparently because he was not able easily to grasp and run his fingers over them and thus take in their form and bulk.

These experiments, which should be repeated with the greatest care whenever opportunity offers, seem to uphold the doctrine of pure psycho-motor centres rather than the sensory, motor or mixed theory. They certainly are not in accord with the view that the motor zones contain centres of the muscular sense ; or that they are areas for pathic or thermic sensibility, or places of confluence of excitations, or centres acted on at a distance by inhibition. The temporary disturbances in sensation may be due sometimes to destruction of association fibres between related sensory and motor areas.

Bechterew* maintains with reason that the loss of sensation in animals who have had the motor area of the convolutions destroyed is apparent and not real ; that they cannot withdraw the irritated extremity though they feel the pain, because they have no control of the muscles. He also considers the loss of the muscle sense only apparent because if the animal's paws be placed in an uncomfortable position, its failure to be removed is due to motor inability rather than impaired muscle sense. The animal will move away if irritated on the affected limb, thus showing that it feels but cannot withdraw the limb except by moving the entire body. He concludes that tactile sensation is behind and external to the motor area, and the centre for muscle sense and pain is at the beginning of the fossa of Sylvius.

In several cases of surgical operation on lesions of the motor zone, it has been claimed that the presence of sensory symptoms supports the opinion that the motor areas subserve a sensory as well as a motor function ; the case of Macewen,† for example, of proto-spasm of the hallux preceded by sensory impressions and followed by paralysis, in which a tubercular nodule, was found in the upper part of the post-central gyre. Such a case may prove contiguity but not coincidence of motor and sensory areas.

The neurologist and surgeon must therefore depend on motor symptoms alone in fixing the site for operation in cases in which motor symptoms are definite. When positive sensory symptoms are present, they should regard these as indicative of the extension of the lesion

* Neurol. Centralbl., Leipz., 1883, ii., 409–414.

† Lancet, Lond., August 11, 1888.

towards either the limbic lobe, or the posterior parietal convolutions ; or the involvement of the fibres going or coming from these gyres in the corona radiata.

We have no clinical or pathological data with reference to the so-called muscular sense of positive practical value to the physician or surgeon. The hypothesis that the cortical motor zone is rather a zone for muscular sense has little to support it either in physiology or in clinico-pathology. I can see no reason for requiring a muscular sense entirely distinct from other acknowledged forms of sensibility. Some facts have been brought forward which are supposed to indicate that a separate cortical area for registering impressions of muscular sense exists in the parietal lobe behind the motor zone, probably in the inferior parietal lobule ; but these observations are not convincing ; they certainly cannot yet be made of value in topographical diagnosis for surgical purposes.

The conclusion is warranted that there is a region for general sensation, including touch, pain, temperature, and possibly pressure, and location of a limb, which can be divided into special sub-areas for the various distinct portions of the body, and that these regions lie along side of and have close anatomical and morphological relations with corresponding motor areas, but that they are not identical with them. From an anatomical and morphological point of view, and from the facts of physiology and pathology, no part of the brain is more likely to contain these differentiated areas for sensation than the gyrus fornicatus, the hippocampal gyre, the precuneus, and the postero-parietal convolutions.

The Pre-frontal Lobe and the Cerebellum.

For the pre-frontal lobe and the cerebellum our diagnostic guides are gradually becoming more definite. We may not be able with the same absolute confidence from positive symptoms and signs to indicate lesions in these localities as we can point to the motor and visual zones, but we often can make the topographical diagnosis with sufficient certainty even for surgical purposes by combining various modes of investigation, as : (1) By a few positive localizing symptoms ; (2) By the general symptoms—such as, in brain tumor, for instance, choked disc, secondary atrophy, headache, vomiting and vertigo ; (3) By excluding lesions of the motor, speech, visual and auditory areas, and their association tracts ; (4) By special pressure and invasion symptoms—invasion by lesions growing from adjacent areas to those under consideration.

Lesions of the prefrontal lobe, although this is one of the so-called latent districts of the brain, have in a large percentage of the carefully

studied cases shown distinctive manifestations. The symptoms are largely psychical, and unfortunately the physician is not usually well trained to study such phenomena. Mental disturbances of a peculiar character occur, such as mental slowness and uncertainty, want of attention and control, and impairment of judgment and reason ; closely studied, the inhibitory influence of the brain both upon psychical and physical action is found to be diminished. Memory is not seriously affected although a continuous train of thought cannot well be followed, and complex intellectual processes cannot be thoroughly performed. The results of experiments upon lower animals have not been very helpful towards determining the existence of prefrontal lesions, because psychical phenomena cannot be studied with accuracy in animals below man. Ferrier,* however, found after removal of the prefrontal lobe a decided alteration in the behavior of animals, difficult precisely to describe. They had apparently lost the faculty of intelligent observation. Horsley and Schäfer,† Hitzig,‡ and Goltz § have also observed apparent mental changes. Phenomena such as these do not measure in usefulness for the average diagnostician with such positive objective manifestations as hemianopsia or Jacksonian spasm, but they should be valuable aids in the hands of close observers. Among pressure and invasion symptoms motor aphasia, nystagmus, contra-lateral paresis, and unilateral convulsions often occur late, particularly in cases of tumor and abscess. Given these symptoms, if now lesions of motor and visual regions can be excluded, it remains only to differentiate the lesions of the cerebellum and possibly some lesions of the temporal lobe.

In cerebellar cases, as shown by the studies of Nothnagel,‖ Seguin,¶ and others, the most positive symptoms are usually choked discs, optic neuritis or secondary atrophy, occipital headache, sometimes increased by percussion or pressure on the occiput or neck, vomiting, often apparently causeless in character ; typical cerebellar titubation, or other disorders of motion or gait ; nystagmus and conjugate deviation ; and among pressure symptoms one-sided paresis, occasional anæsthesia, sometimes disturbance of temperature, pulse, respiration, and deglutition.

Some lesions of the cerebellar hemispheres as in cases reported by Hun ** give no localizing symptoms.

* Functions of the Brain. † Op. cit. ‡ Quoted by Ferrier.

§ Quoted by Ferrier.

‖ Topische Diagnostik der Gehirnkrankheiten, p. 78. Berlin, 1879.

¶ Jour. Nerv. & Ment. Dis., vol. xiv., No. 4, April, 1887, 217–235.

** Albany Medical Annals, May, 1888.

It might be of value to attempt a contrast of the usual symptoms produced by lesions in these localities. In pre-frontal disease psychic symptoms of the peculiar character just described, are usually present; in cerebellar affections they are as commonly absent, although irritative lesions of any part of the encephalon may, of course, cause emotional mental disturbance. The station or gait is not affected in pre-frontal cases: in cerebellar lesions, either typical titubation or some form of ataxia or staggering is usually present. Cerebellar titubation is characteristic of a destructive lesion of the middle lobe of the cerebellum, and when lesions of the cerebellar hemispheres are present, this results from pressure or encroachment. Bulbar symptoms and symptoms of pressure on the bulbo-spinal tracts, both sensory and motor, are somewhat frequently present in cerebellar lesions, particularly late in the history of a lesion of large size. With pre-frontal lesions of large size, the pressure and invasion symptoms are more likely to be disturbances of speech or smell, facial, brachial, or aural paresis, and unilateral spasm. Carefully recorded cases show that nystagmus, and conjugate deviation may be present in both pre-frontal and cerebellar cases; but in the pre-frontal cases the latter is more likely to be towards the side of the lesion presumably destructive rather than irritative; in cerebellar cases more probably the reverse. Headache is more likely to be frontal in the pre-frontal, and occipital in the cerebellar. Elevation of local surface temperature, and tenderness on percussion, have some, but no great value in differentiation.

Auditory Localization.

While auditory localization remains in a somewhat uncertain state, on the whole, the evidence is in favor of the localization of the cerebral centres or area, of hearing in the temporal lobe, and probably in its upper portion, that is, in the first or second, or in both the first and second, temporal gyres. The most recent and interesting discussion of this subject has arisen from the reports of the results obtained by Schäfer in his experiments on special sense localization in the cerebral cortex of the monkey. Dr. Ferrier* in reviewing the paper of Prof. Schäfer, attacks the results obtained and the conclusions drawn by the latter, and contends stoutly for the localization of the centre of hearing in the temporal lobe, and in accordance with his original view, more especially in the superior convolution of that lobe. Dr. Starr, in his consideration of aphasia, will doubtless discuss at length the question of auditory centres, naming centres, speech association

* Brain, January, 1888.

tracts, and speech centres, and I will, therefore, only briefly and for the purpose of completeness refer to this portion of the subject. Schäfer claims to have more or less completely destroyed the superior temporal gyre on both sides in six monkeys, and in one of the animals to have removed every trace of the convolution on both sides. In these cases he reports that hearing was not permanently affected, so far as it is possible to determine in monkeys, and concludes that the auditory faculty is not localized in the superior temporal convolution. In one experiment of Horsley and Schäfer, the superior temporal convolution was almost completely removed on both sides; in this case the animal appeared to hear quite distinctly, so far as it went the experiment being at variance with the results of Ferrier and those of Munk. The experimenters, however, say that they do not claim to have obtained direct corroboration or refutation of the views of Ferrier, but regard the question as still open.

Ferrier reaffirms his position, and reproduces with some additional facts, his original experimental evidence in favor of auditory localization in the temporal lobe, and particularly in its superior convolution. Munk, who is quoted both by Ferrier and Schäfer, extended the area for perception of auditory impressions over the entire temporal lobe; and Luciani believes that lesions of the temporal lobe in dogs produce abolition or impairment of hearing.

Gowers* refers to an interesting case of extensive tumor in which the oldest part was beneath the first temporal convolution. In this case convulsions, commencing by an auditory aura referred to the opposite ear, were a very early symptom. In another case of tumor of the first temporal convolution and Sylvian fossa, unilateral convulsions were preceded by a loud noise as of machinery. He notes that the loss of deafness in such cases is not permanent; that perfect compensation seems to be possible, presumably by the corresponding centre of the opposite side; and that each auditory nerve must be structurally connected with both hemispheres, although only the connection with the opposite hemisphere is habitually in functional action.

The pathological evidence with reference to the existence of auditory centres is not extensive or very decisive. That complete deafness from cerebral disease may occur probably requires, as Ferrier states, the existence of symmetrical lesions in both temporal lobes. It has, however, been clearly established by reported cases, that the so-called word-deafness may result from lesion of the upper convolution or two upper convolutions of the *left* temporal lobe. Cases in

* Manual of Diseases of the Nervous System, p. 454.

which the power to understand spoken words has been lost or impaired with lesions, in part at least, in the temporal lobe have been reported by various observers as, for instance, by Seppilli, Monakow and Amidon.

Ferrier * refers particularly to two cases in support of his position, one reported by Shaw† and one by Wernicke and Friedlander.‡ Shaw's case, a woman, aged 34, two months before her admission into his asylum, lost power in the right arm, and soon after had a sudden apoplectic seizure resulting in loss of speech and deafness. The loss of power in the right arm soon passed off. She became incoherent, more or less maniacal and demented. On admission she was found to be perfectly deaf and blind. She died of pneumonia a year afterwards. Post-mortem examination showed complete atrophy of the angular gyri and superior temporo-sphenoidal convolutions of both hemispheres. The gray matter of the atrophied regions had entirely disappeared, leaving the outer layer attached to the pia mater, with a cavity underneath formed at the expense of the gray matter. The cranial nerves were normal in appearance, the optic nerves showed increase of the connective tissue septa, atrophy of the nerve fibres, and spaces filled with a colloid-like material.

Wernicke and Friedlander's case, a woman, aged 43, had never suffered from deafness or affection of vision, and was attacked June 22nd, 1880, with right hemiplegia and aphasia. She remained in the hospital until August 4th, when she was discharged. At this time the patient could speak but unintelligibly, and was sometimes believed to be intoxicated. She not only could not make herself be understood but she could not understand what was said to her. She was received into the hospital again on September 10th, with slight paresis of the left arm. The right hemiplegia had entirely disappeared. The patient was looked upon as insane, and was absolutely deaf so that she could not be communicated with. She died of an attack of hæmatemesis on the 21st of October. An extensive lesion was found in each temporal lobe, invading the superior temporal convolution on both sides. The rest of the brain and the cranial nerves exhibited no abnormality. It was proved that the patient had previously enjoyed excellent hearing. Her total deafness occurred rapidly in connection with the other indications of cerebral disease.§

* Brain, xii., London, April, 1888, p. 18.

† Archives of Medicine, Feb. 1882.—Abstract in Brain, vol. v., 1882–83, p. 430.

‡ Fortschritte der Medicine, Band I., No. 6, March 15, 1883.

§ With Dr. Roland G. Curtin, of Philadelphia, I exhibited at the Philadelphia Pathological Society, the brain of a man for many years a deaf mute. A description of this brain, with illustrations, will be published with the reports of some other specimens referred to in this paper, in a forthcoming number of the University Magazine. On

Large Lesion of the Temporal Lobe.

With a large lesion of one temporal lobe, as tumor, hemorrhage or abscess, the diagnosis is best made by a careful consideration of pressure and invasion symptoms in addition to those which are strictly localizing in character. A single case recently published by Dr. Bodamer and myself, will perhaps best illustrate this mode of diagnosis. The chief symptoms were severe headache, more localized in the temporo-frontal region; pain on localized percussion; impairment of sight and hearing; choked discs; dilatation of the right pupil, and three days before death paralysis of the left arm and paresis of the left leg, and aphasia. The autopsy showed a large lesion centred in the middle of the right second temporal gyre; it was a vascular glioma, having beneath and partly around it a cavity containing detritus, and a large and evidently recent clot. It occupied a large portion of the interior of the right temporal lobe, but was strictly limited to it.

Macewen reports an operation on a somewhat similar case, of a lesion definitely localized in the temporo-sphenoidal lobe. A patient exhibiting symptoms of cerebral abscess had, on the left side ptosis, stabile mydriasis, paresis of all the ocular muscles, with the exception of the external rectus, without external squint; on the right side, paralysis of the facial muscles, which retained emotional expressions to a slight degree, and power to close the right eyelid by an effort of will, although it remained partially opened during sleep. He had, also, paresis of the right arm, which during the few hours he was under observation before operation, had amounted to distinct paralysis. The leg remained normal, and there was no diminution of cutaneous sensibility.*

the whole, the gross appearances could be regarded as favoring strongly Ferrier's auditory localization. The first temporal convolution of the left hemisphere was narrow and lacking in gyral elaboration; it was apparently distinctly atrophied or arrested in development. The first temporal convolution of the right hemisphere was smaller than usual, but it did not present the marked smoothness and diminution in size shown by the corresponding convolution of the other side. The brain was compared directly with half a dozen other specimens, normal and abnormal, and was examined by several brain anatomists and morphologists, who agreed with me as to the striking appearance of lack of development of the first left temporal. Other peculiarities of the temporal, third frontal, and central convolutions, the island of Reil, etc., were noted, and will be given in the description of the specimen.

* While this paper is passing through the press, through the courtesy of Dr. H. C. Wood, of Philadelphia, I have had the opportunity of seeing a case of large lesion of the right temporal lobe which shows how active symptoms of such lesions may be absent for a long period, or if present how they may differ from the pressure and invasion symptoms in the two cases above given. Dr. Wood will publish a full account of this interesting and important case. The patient had had for many months general

Tumor of the Facial and Auditory Nerves.

At the meeting of the Neurological Society, of London, March 15, 1888,* Dr. Sharkey read notes and showed the brain of a case of tumor of the auditory nerve. During the discussion of this specimen, Mr. Horsley stated that the tumor might have been removed by an operation he had already advocated—namely, incision of the tentorium and ligature of the lateral sinus. I have made two dissections with a view of determining whether a tumor in the intra-cranial course of the facial and auditory nerves can be removed, and have concluded that it could, and best, not by operating above the tentorium as I understand Mr. Horsley's suggestion, but by operating below the tentorium, and then pushing aside or excising an outer segment of the cerebellar hemisphere.

Olfactory Localization.

The location of the cortical centre of smell is still uncertain, but the pointings are all towards the region of the uncinate convolution and its immediate vicinity. Zuckerkandl, of Gratz, in 1887, published a monograph on the olfactory centre, the work being anatomical and physiological, not clinical. The anatomical portion is largely comparative, considering the brains of twelve varieties of animals besides man. One chapter describes the cornu ammonis region, another the olfactory lobes of animals and man, etc. The writings of Burdach, Treverinus, Huguenin, and Ferrier are largely quoted. Zuckerkandl

symptoms of brain tumor, such as headache, choked discs, vertigo, etc., but no paralysis; and no loss of hearing that could be detected by ordinary tests. During the absence of the patient from the city, left homonymous hemianopsia developed, with pronounced contraction of the other visual fields. Wernicke's hemiopic pupillary inaction was carefully tested for, but was certainly not present. Operation was performed by Dr, D. Hayes Agnew for Dr. Wood, and a cyst in the right occipital lobe was discovered and removed. After death a large fibro-glioma was found occupying almost the entire second and third temporal convolutions, and also invading the central portion of the first temporal, the superior aspect of which was somewhat flattened by pressure. The fourth and fifth temporal convolutions were apparently not greatly encroached upon, the uncinate convolution escaping entirely. The patient had no loss of smell. The occipital cyst was evidently a radiation or a secondary result of the growth, due to softening from obliteration of blood vessels. This case emphasizes the great importance of carefully studying pressure and invasion symptoms with reference to such comparatively latent regions as the temporal, (particularly the right temporal), and pre-frontal lobes. The pressure in this case was evidently not exercised in the same direction as in the two cases referred to above. In a lesion of a so-called latent region, the pressure and invasion symptoms will depend both upon the nature of the growth, and on the particular direction in which it happens to develop.

* Lancet, London, April 7, 1888.

believes, but, I think without reason, that the entire limbic lobe is the seat of olfactory sensation. Among other cases, he has collected two in which infants born without the olfactory lobe on one or both sides, showed arrested development of the horn of Ammon, and in both of which the gyrus fornicatus and hippocampus were small.

Zuckerkandl, in this view, is simply following Broca, who divided all animals into osmatics and anosmatics, or good smellers or bad smellers, and believed that the whole of the falciform or limbic lobe was the cerebral organ of smell. I cannot here go into the anatomical and physiological arguments bearing upon this subject. To one familiar with brain anatomy a knowledge of the relatively large size of the gyrus fornicatus and hippocampal region in an animal like man, in whom the sense of smell plays so comparatively an unimportant part, is an argument of some weight against the view of Broca. In osmatics, however, the hippocampal lobule or region of the amygdala—the uncinate convolution so-called—is very large while in the anosmatics it is comparatively small. Ferrier's view is therefore probably correct that the only relationship which undoubtedly exists is between the olfactory bulb and the anterior portion of the hippocampal convolution. The anterior commissure has an anterior and posterior division, which connect respectively the olfactory bulb and the region of the hippocampal lobule and nucleus amygdala, a fact which also tends to prove that the anterior portion of the hippocampal convolution is the cortical organ of smell.

Electrical irritation of the hippocampal lobule or uncinate gyrus in monkeys, cats, dogs, and rabbits furnished Ferrier with significant indications of subjective olfactory sensations. This reaction, the same in all, as described by Ferrier, was a peculiar torsion of the lip and nostril on the same side. The experiment in which Ferrier produced destructive lesions of the hippocampal lobule, were, on the whole, unsatisfactory, but to a certain extent supported the view that this region contained the centre for smell.

Few autopsies have been recorded in which loss or diminution of smell has been present as the result of cerebral lesion. Ferrier, however, refers to cases reported by W. Ogle, Fletcher and Ransome, of the occurrence of the loss of smell in the left nostril with right hemiplegia and aphasia; and he also alludes to cases reported by Hughlings Jackson. From a study of these cases he believes that we have reason to regard anosmia as probably due to softening of the region of the hippocampal lobule. The connections of the olfactory tract are with the hemisphere on the same side. In some cases of cerebral hemianæsthesia, as in the hysterical and alcoholic forms, impairment

or loss of smell is present and seems to be contra-lateral. This, Ferrier believes, may be explained on the supposition that the defect was due to an anæsthetic condition of the nostril, either from lesion of the fifth nerve or of the centres for cutaneous sensation in the cerebral hemisphere. Close testing in such cases would probably show that the olfactory sense was not absolutely abolished.

Various cases have been reported with autopsies in which the presence of an olfactory aura has been accompanied by a lesion of the temporal lobe, and these cases, on the whole, point to the lower convolutions of this lobe as the probable seat of the centre of smell.

Hughlings Jackson has written various papers showing the great importance of studying all forms of aura in order to be able better to localize the lesions in the encephalon. As early as 1876, and again in 1879, he considered the varieties of epilepsy in which not only crude sensations or warnings of smell, taste, etc., were present, but also a more elaborate mental condition which he speaks of as the "dreamy state." As theoretical as such discussions may seem at first sight, he clearly shows that they are of practical value not only in leading to an early recognition of epilepsy, but also in localizing lesions in either epileptic or epileptiform cases.

I have had several epileptic patients in whom the attacks were initiated by an odor usually offensive. Jackson* gives interesting histories of three such cases in which attacks were ushered in by a crude sensation warning of smell, accompanied sometimes by other warnings as epigastric sensations, and the dreamy state. These cases are of great clinical interest but are not accompanied by autopsies. He refers, however, to the necropsy of a woman who had had paroxysms with the dreamy state and crude sensation warnings of smell. She had left hemiplegia and double optic neuritis. The autopsy showed a tumor in the right temporo-sphenoidal lobe.

Allan McLane Hamilton† has reported the following case of softening of the temporo-sphenoidal lobes, in a woman of forty years. The patient suffered from the age of ten from epileptic attacks, which occurred four or five times a year, and consisted of general convulsions. The first attack occurred after a fall when she struck her head, and was unconscious thereafter for some hours. No scar was visible on the head. She always had an aura of a peculiar character before the attack. She suddenly perceived a disagreable odor, sometimes of smoke, sometimes of a fetid character, and quite uncomplicated by other sensory warnings. She died of phthisis.

*Brain, July, 1888. † Am. Jour. Med. Sci., April, 1884. Quoted by Starr.

On post-mortem examination the dura mater was thickened and opaque in spots, and at the base was adherent to the temporo-sphenoidal lobes. The adhesion of the membranes was most marked on the right temporo-sphenoidal lobe somewhat posterior to its apex. At this point a decided shrinkage of tissue was discovered with depression, the induration involving the uncinate gyrus and parts of the adjacent convolutions. The basal ganglia and motor tracts were normal, and the olfactory nerves were not involved.

Worcester* reports the case of a farmer, aged 30, who had had epilepsy for two years before admission to the hospital. The case presented no special features until January 26, 1878, when after a severe convulsion the man remained in a state of alarming collapse. Radial pulse was almost imperceptible, surface cold, and there appeared danger of immediate dissolution. He rallied somewhat under stimulants, but remained for three days in a stupid condition unable to be long out of bed. Shortly after the attack slight innervation of the right side of the face was observed, but only when the muscles were called into action as in talking and smiling. On February 11th, he regained his ordinary mental condition. No paralysis was discovered except as above mentioned, and no impairment of sensibility except a transient numbness of the hand at times. For several days hallucinations of smell—at first constant, afterwards transitory, were present. Once he imagined the room was full of smoke. He fancied at times there was an odor like the vapor of alcohol passing quickly. He thought this took the place of a convulsion. No test was made of his sense of smell. No marked changes occurred until his death on February 28th, after a series of tonic convulsions, with marked opisthotonos, affecting chiefly the muscles of the back.

The autopsy revealed, on inspection of the inferior surface of the brain, a small red spot of softening at the most prominent point of the left gyrus uncinatus. The brain was not opened until it had been hardened in alcohol. A focus of softening existed in the white matter of the anterior part of the left temporal lobe, extending to the surface, externally, and internally involving the pes hippocampi in the floor of the descending cornu of the lateral ventricle. The portion of the hippocampus major not discolored, was swollen and softened. A very small focus of softening, without discoloration, about the size of a large pea, was found in the white matter of the frontal lobe on the same side. No other gross lesions were discovered, but the perivascular spaces were very generally dilated, so as to give thin sections of the brain a worm-eaten appearance.

* American Journal of Insanity, for July, 1887.

Gustatory Localization.

Our knowledge of a cerebral centre for taste is even more unsatisfactory and undecided than that for an olfactory centre. Morphology, anatomy, physiology and pathology combine to indicate that this centre is probably situated close to and in the same lobe of the brain as that for smell. The experiments of Ferrier seemed to show that affections of both taste and smell were evidently connected with lesions of the hippocampal lobule and its neighborhood. "It was noted in connection with electrical irritation of the lower extremity of the temporo-sphenoidal convolutions in the monkey, and of the same region in the brain of a cat, that the movements of the lips, tongue, cheek-pouches and jaws were occasionally induced—phenomena which might be regarded as indications of the excitation of gustatory sensation. This interpretation receives support from the above described results of destructive lesions; and we have, therefore, reasonable grounds for concluding that the gustatory centres are situated at the lower extremity of the temporo-sphenoidal lobes, in close connection with those of smell. This would enable us to explain the occasional occurrence in man of anosmia and ageusia as the result of severe blows on the head, especially the vertex. A blow in this region causes counter-stroke of the base of the brain, particularly in the region of the olfactory centres."

Dr. James Anderson* has recorded a case of epilepsy in which, from symptoms, ocular and cerebral, detailed in his report, he correctly predicated tumor and its position. The patient's dreamy state was associated with a rough, bitter sensation in his mouth. It is the only case published, according to Jackson, in which a necropsy has been had revealing any local morbid changes in a case of the variety of epilepsy mentioned. Dr. Anderson refers to a case, closely like that of his own patient, recorded by Mr. Nettleship. In the report of this case, however, the dreamy state was not mentioned; there was a crude sensation warning in the patient's fits—a sudden feeling of suffocation in the nose and mouth.

As our special subject is the practical relations of cerebral localization, I cannot forbear to recall here the advice of Hughlings Jackson† on the great practical importance of the close study of epileptic seizures. These remarks are made in connection with the discussion of the different varieties of aura—crude warnings of smell and taste, intellectual aura of the dreamy state, temporary word-blindness or

* Brain, October, 1886. Quoted by Hughlings Jackson in Brain, July, 1888.

† Brain, July, 1888.

word-deafness, noises, flashes of light, hallucinations, etc. No better neurological work, Jackson holds, can be done than the precise investigations of epileptic paroxysms. The efforts should be to describe *all* that occurs in the paroxysms. Epilepsies are as numerous as are paroxyms beginning with different warnings. The warning is the first event from or during the onset of the epileptic discharge ; it is the clue to the seat of the discharging lesion. Using the term suggested by Seguin, I might interpolate here that it is the sensory "signal symptom." The discharging lesions have as many different seats as there are different warnings of the paroxysms.

"Before we can make good generalizations," says Jackson, "we must carefully analyze. To group together as 'visual warnings' color projections, apparent alterations in the distance of external objects and 'dreamy states' with definite scenes, is generalizing without previous analysis, and is an attempt to organize confusion ; they are exceedingly different things. He who is faithfully analyzing many different cases of epilepsy is doing far more than studying epilepsy. The highest centres ('organ of mind'), those concerned in such fits, represent all, literally all, parts of the body sensorily and motorily, in most complex ways, in most intricate complications, etc. A careful study of many varieties of epileptic fits is one way of analyzing this kind of representation by the 'organ of mind.' Again, it is not, I think, an extravagant supposition that there are, after slight epileptic fits of different kinds, many temporary morbid affections resembling those persistent ones produced by destructive lesions of different parts of the cortex. To illustrate for a moment by epileptiform seizures ; there is temporary aphasia after some fits beginning in the face or hand (more 'elaborate' utterances, I think, when the exact starting point is in the ulnar fingers) ; this is the analogue of aphasia from a destructive lesion (softening, etc.). To return to epilepsy. There is, I am convinced, in, or after, certain paroxyms of epilepsy temporary 'word-blindness ;' certainly in one patient of mine who had a 'warning' by noise. I could not make out that this patient was at the same time 'word-deaf,' but thought his temporary deafness was ordinary deafness. Still there may have been word-deafness. In another patient who called his attacks 'losses of understanding,' there was clearly both 'word-deafness' and 'word-blindness,' with retention of ordinary sight and hearing ; this patient's attack used to begin with a warning noise, but he has recently had his 'losses of understanding' without that warning."

Jackson holds that there is some local disease in every epilepsy, some pathological process productive of high instability.

His views on the arterio-cortical pathology of some varieties of epilepsy or epileptiform seizures are of great importance to those who are concerned not only in locating the site of a discharging lesion, but also in deciding whether such lesion shall be removed by operation. Sometimes, in the cases already operated on, even when the most careful, and doubtless accurate, localization has been made no gross lesion has been discovered, and yet even in these cases a true gross lesion may have been present—if the plugging of arterioles can be regarded as a gross lesion. Jackson believes that most cases of epilepsy proper are due to the plugging of arterioles. His views upon this question are full of suggestive value. "Centres of taste and smell," he says, "lie, according to Ferrier's localization, in the region of the posterior cerebral artery, whilst, still according to his localization, the centres for hearing and part of the centre for sight (angular gyrus) lie in the region of the middle cerebral. Hence, if arterial plugging be the pathology, it may be that we have different varieties of epilepsy proper, according as arterioles are plugged in different vascular regions. The variety of epilepsy I am remarking upon in the text may be owing to morbid changes in the district of the posterior cerebral. But tumors would grow regardless of vascular regions. I suggest that cases of epilepsy with mixed warning (of smell or taste along with the warnings of color) are more likely to be owing to tumor or other gross organic disease."

Handicapped by the embarrassing proportions of my subject, I have imperfectly presented it for consideration ; but trust that my remarks may open lines of discussion to those here present far better fitted than I to enter the lists in such a debate. These practical discoveries in cerebral localization, with the achievements of antiseptic surgery, constitute the grandest triumphs that adorn the history of our noble science and art of medicine.

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